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Contents of this Issue

Page

Twin Branch Carries Base Load. Illustrated....118
Automatic Control at Cahokia. By H. T. Lange. Illustrated.128
Higher Steam Pressure and Temperatures. Illustrated.....131
Standard for Steam Costs Needed. By W. J. Risley, Jr.....133
Overhauling the Main Turbines at Connors Creek. Illustrated....135
Reasons for Oil Engine Failures. By C. H. S. Tupholme.....137
Centrifugal Compressors for Diesel Engines.....139
Motor Drives for Centrifugal Fans and Blowers. By Gordon Fox. Illustrated....141
Large Synchronous Condenser Installed on West Coast.....144
High-Speed Motors and Frequency Changers. By Charles Fair. Illustrated....145
Pneumatic Sweeping Systems in Power Plants. By F. C. Allen, Jr. Illustrated....147
Welds Made Stronger than the Welded Material. By H. A. Woodworth. Illustrated....149
Many Factors Influence Ice Plant Design. By H. J. Macintire. Illustrated....151
Safety Work in Ice Plants. By George Steers, Jr.....154
District Heating Rates for Varying Conditions.....155
Steam Generator of Unique Design Gives High Ratings.....157
Improvements at the Miami Paper Co. Illustrated.....158
Running Them on Water. By W. L. Johnson.....161
Letters Direct from the Plant: Trouble Shooting in D. C. Motors and Generators. Common Sense Needed for Pipe Fitting. Bags in Boiler Shells Due to Lifting of Water. Burning Out Motor Is Expensive. Making a Serviceable All-Steel Work Bench. Illustrated....162
Questions and Answers: Currents and Resistances in Closed Network. Superheater for H. R. T. Boiler. Electrolytic Corrosion in Boilers. Boiler Plates Bowed Up by Oil on Tubes. Illustrated....165
Editorial Comment: Differences Count in Men and Power Plants. The Automaton Enters the Power Plant. We Are Moving Forward....168
Off Duty....169
Midwestern Engineering and Power Exposition. Illustrated..170
Electric Welding Used in Constructing Lincoln Motor. Illustrated....179
Low Water Alarm for Small Boilers. Illustrated.....180
High-Speed Blower Ruggedly Built for Forced Draft Service. Illustrated....180
"Forgsteel" Valve for High Pressures and Temperatures. Illustrated....181
New Sewage Pump Design Permits Easy Inspection. Illustrated....181
Mercury Contact Switch Used on Pyrometer Recorders. Illustrated....181
Sand Blast Flue Cleaner for H. R. T. Boilers. Illustrated....182
Valves for 225-lb. Service Incorporate New Features. Illustrated....182
Automatic Change-Over Switch Guarantees Continuity of Service. Illustrated....183
Technical Societies of Massachusetts Hold Two-Day Session.183
Work Begins on Pit No. 4 Hydro Plant.....183
Monel Metal Whistle Valve of Compact Design. Illustrated..183
Maine Power Law Meetings Disfavor.....184
Hydro Plant for Small Powers Uses Propeller Runner. Illustrated....184
News Notes....184
Books and Catalogs....186

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Arterio-sclerosis

EVEN SUCH a husky thing as a turbo-generator is not immune from the infirmities and diseases of old age. Glance at the photograph shown above for a moment; what does it look like? To a physician it would suggest nothing else but an advanced case of arterio-sclerosis, or to translate from the medical, hardening of the arteries.

When a person becomes old, in consequence of many toxic agencies as part of a senile change and as the effect of long continued stress, the vascular system suffers a loss of its normal properties. The walls of the blood vessels thicken, become hard and weaken; sometimes they burst. That's apoplexy.

In an electric generator, as the years and the kilowatts roll by, the insulation of the windings, under prolonged action of heat, potential stress and windage, gradually deteriorates. It loses its resiliency, the surface scales off, it becomes hard and weakens; sometimes it bursts. That's a short circuit.

The pathology of the case depicted above fortunately did not prove fatal, but as explained on page 135, extensive surgical attention was necessary.

Twin Branch Carries Base Load

NEW PLANT OF AMERICAN GAS & ELECTRIC CO., AT MISHAWAKA, IND., USES NO CIRCULATING PUMPS, HAS HYDRO PLANT AS AUXILIARY HOUSE GENERATOR AND OTHER INTERESTING FEATURES

BY UTILIZING NATURAL resources and designing the plant to operate as a base load station, following the basic principles employed at the Philo Station* and installing for the most part the same types, sizes and arrangement of equipment, the American Gas & Electric Co. has constructed its new Twin Branch Plant at Mishawaka, Ind., to perform for that part of its vast interconnected transmission system the same service that Philo performs for the southern sections. With a fuel consumption ranging between 13,715 and 14,300 B.t.u. per kw-hr., the Philo Station has aroused a great deal of interest in the engineering world and, since the Twin Branch plant is practically a duplicate of it, the same satisfactory performance is to be expected there. Like Philo, Twin Branch is a manufacturing plant for the production of electric power, delivering this power to the outgoing side of the transformer, where it is taken in charge by the purchaser or distributor. The same organization of stores, accounting and repair departments is used, forming a complete manufacturing organization. It is the purpose of this article to discuss briefly the points of difference and similarity between the two plants.

As has previously been explained in these columns* it was possible at Philo to take advantage of the flow of water in the Muskingum River in such a way that, although condenser circulating pumps are installed there, they are operated only 2 or 3 mo. each year, thus making an important saving in operating charges. At Twin Branch, located on the St. Joseph River at Mishawaka, Ind., near a dam and hydro-electric plant already built there, it was possible to carry this idea a step farther and to eliminate entirely the need for circulating pumps, which are not even installed in the station. Thus, in addition to the saving in operating charges there is a large saving in fixed charges on the investment for these pumps. Another interesting feature at Twin Branch is the use of the existing hydro-electric plant as a floating house generator. Feed water treatment apparatus was omitted at Twin Branch and certain other changes in the Philo plans were made which will be discussed in more detail below.

* "Philo Station Establishes Record of Economy," Power Plant Engineering, June 1, 1925, page 573.

FIG. 1. CONTROL ROOM OVERLOOKS TURBINE ROOM ON ONE SIDE AND SWITCH YARD ON THE OTHER

AT PRESENT ONE UNIT CARRIES BASE LOAD OF PART OF SYSTEM

At the present time, one 40,000-kw. turbo-generator unit is being operated at Twin Branch, to assist in taking the base load of that part of the American Gas & Electric Company's system. The No. 1 unit went into operation in June, 1925, and the No. 2 unit the following August. Both machines have been in commercial operation, but due to the present load conditions on the system, only one machine is run at a time, the other being held in reserve. The No. 1 battery of boilers is being used to drive these machines, while the installation of the No. 2 battery is still being carried forward, therefore the station should be con-

sidered as still under construction, even though its generating units are now operating.

The reheat boiler of the No. 1 battery has not yet been put into operation, and therefore no operating data that could be obtained now would give an accurate idea of what will ultimately be expected at Twin Branch. The purchase and construction of the reheat boiler for the No. 2 battery will not be undertaken at the present time, space being reserved, however, for this piece of apparatus which is to be installed at some future date.

Twin Branch Station was designed, like Philo, for an initial installation of two 40,000-kw. turbo-generators, the ultimate capacity to be six 40,000-kw. units, and the coal handling, water circulating and power distributing systems being laid out on that basis. The building is constructed from the same plans as those of Philo, the design and appearance being the same. A temporary wall on one side will allow expansion of the station along the river bank, as new units are added. Points of difference and similarity between the two will be evident upon comparing the lists of equipment, drawings and photographs of Twin Branch with those of Philo.

Twin Branch Station is located on the St. Joseph River at Mishawaka, Ind., about 7 mi. from South Bend, Ind. The Indiana & Michigan Electric Co., a subsidiary of the American Gas & Electric Co., had been operating a system composed of a steam plant of about 25,000-kw. capacity, at South Bend, and four separate hydro-electric plants* with a total generating capacity of 21,700 kw., together with a large outdoor 132-kv. substation. It will be remembered that at Philo an unused canal formed a convenient coal storage space, but no such canal existed at Twin Branch. Nevertheless the coal handling and storage equipment were laid out on almost the same basis as those at Philo except that all coal is stored dry. Figures 11E and 12 show this arrangement.

* The hydro plants referred to are as follows: (1) at Twin Branch 7,260 kw.; (2) at Elkhart, Ind., 3,440 kw.; (3) at Buchanan, Mich., 3,800 kw.; (4) at Berrien Springs, Mich., 7,200 kw.

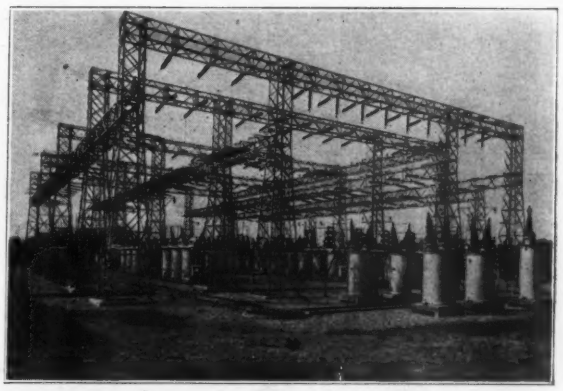


FIG. 2. FROM THE 132-KV. SWITCH YARD, THE TRANSMISSION LINES RUN TO THE SO. BEND SUBSTATION

Coal used at Twin Branch is for the most part from Indiana mines, averaging 10,500 B.t.u. per lb. All coal is brought in by rail, weighed on a Howe track scale and dumped into track hoppers feeding apron conveyors which take it to the crusher house. Here the coal is crushed to about 1½ in. and fed to another belt conveyor, running the whole length of the storage space. Coal may be unloaded from this conveyor at any point and distributed in the storage space by a gantry crane, or it may pass directly to the No. 2 crusher house at the power house end of the conveyor. Here it is crushed to stoker size and sent by two other belt conveyors to the boiler house bunkers. Coal is reclaimed from dry storage by the gantry crane and placed on the conveyor to No. 2 crusher, a screen on the crane hoppers allowing fine or coarse coal to be put on the belt. The coal handling equipment is rated at 600 t. an hour. Crane motors are d.c.; obtaining power from motor-generator sets in the coal yard substation near No. 2 crusher house; this substation is shown in Fig. 6. Coal is stored

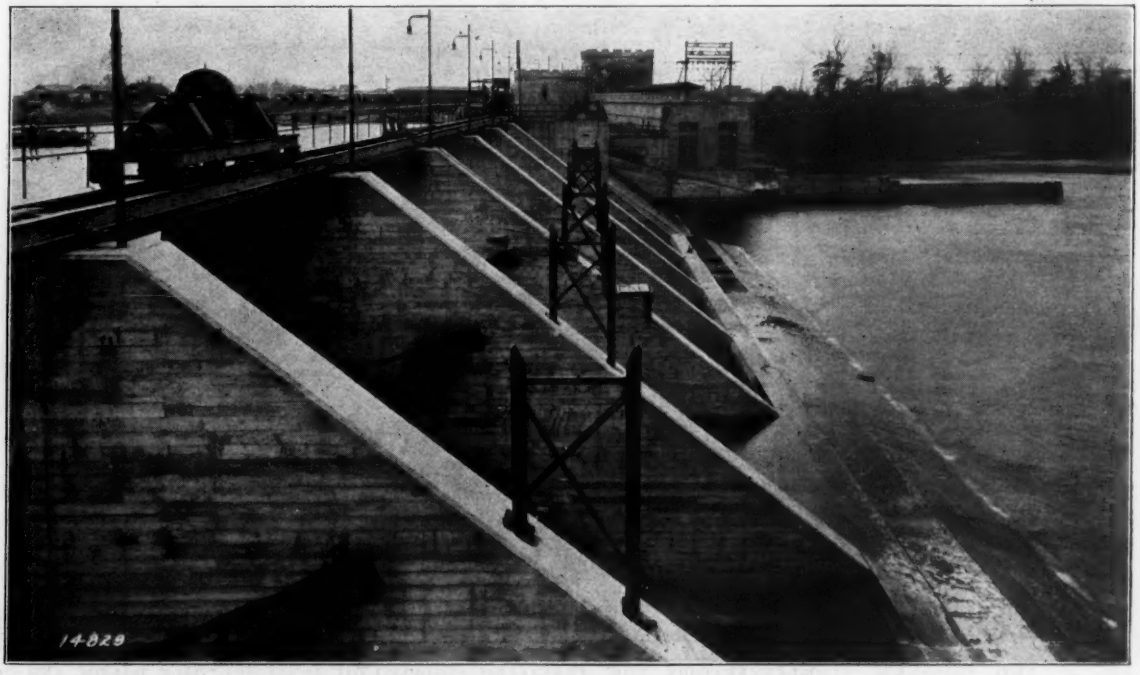


FIG. 3. THIS HYDRO-ELECTRIC PLANT SERVES AS AUXILIARY HOUSE GENERATOR AND FEEDER SUPPLY

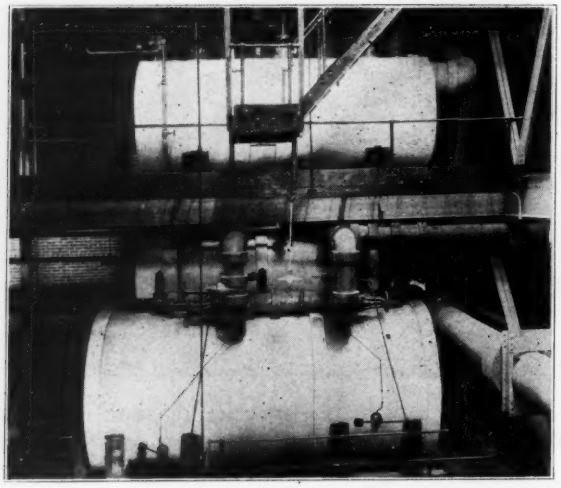


FIG. 4. THIS OPEN HEATER (ABOVE) AND THE DEAERATOR BELOW IT SERVE NO. 2 UNIT

dry, space being provided at present for storage of about 150,000 t., which will serve half the ultimate total plant.

Coal passes on the belt conveyor to the storage bunkers in the boiler room. These bunkers are of steel plate with concrete lining, with a capacity of about 250 t. each. From these the coal is fed through spouts to the chain grate stoker hoppers, in which it is distributed either by swinging the spouts or by means of screw spreaders.

Standard boilers are of the Babcock & Wilcox cross drum water tube type, designed for 650 lb. gage pressure and containing 14,086 sq. ft. of heating surface and an inter-deck convection type superheater of 2485-sq. ft. heating surface, giving a total steam temperature of 725 deg. F. Combustion space of 5430 cu. ft. is provided in the furnaces.

Reheat boilers, one of which is installed at present but is not yet operating, consist of a high pressure steam generating unit and a reheat section. The high pressure part is in two decks, as shown in Fig. 9, having 5031 sq. ft. of heating surface with a 2485 sq. ft. superheater between the decks. This section of the boiler generates steam at 650 lb. pressure and 725 deg. in parallel with the three standard boilers described above. Above the generating section is the reheat section, a series of bent tubes connected to three cross drums as shown in Fig. 9. Steam from the 7th stage of the turbine enters the lower drum at 150 lb. gage and leaves the top drum at 725 deg., total temperature, going thence to the 8th stage of the turbine, where its pressure is 147 lb. There is no steam connection between the standard and reheat sections of the boiler except through the first 7 stages of the turbine. The standard section of this boiler has a steam generating capacity of about 75,000 lb. per hr. at 650 lb. pressure and the reheat section has a normal capacity of 310,000 lb. per hr. Furnaces are equipped with Detrick arches 10 ft. long; a short rear arch narrows the throat to 7 ft. 9 in., the distance from the grates to the first row of tubes being about 20 ft. Stokers for all boilers are of the chain grate type, driven by d.c. variable speed 230-v. motors. Power for these motors, and for coal spreader motors, valve-operating motors, and boiler room crane is supplied by two motor-generator sets installed in the boiler room.

Stokers for boilers supplying No. 1 turbine unit are of the Coxe chain grate type, two stokers being used in one

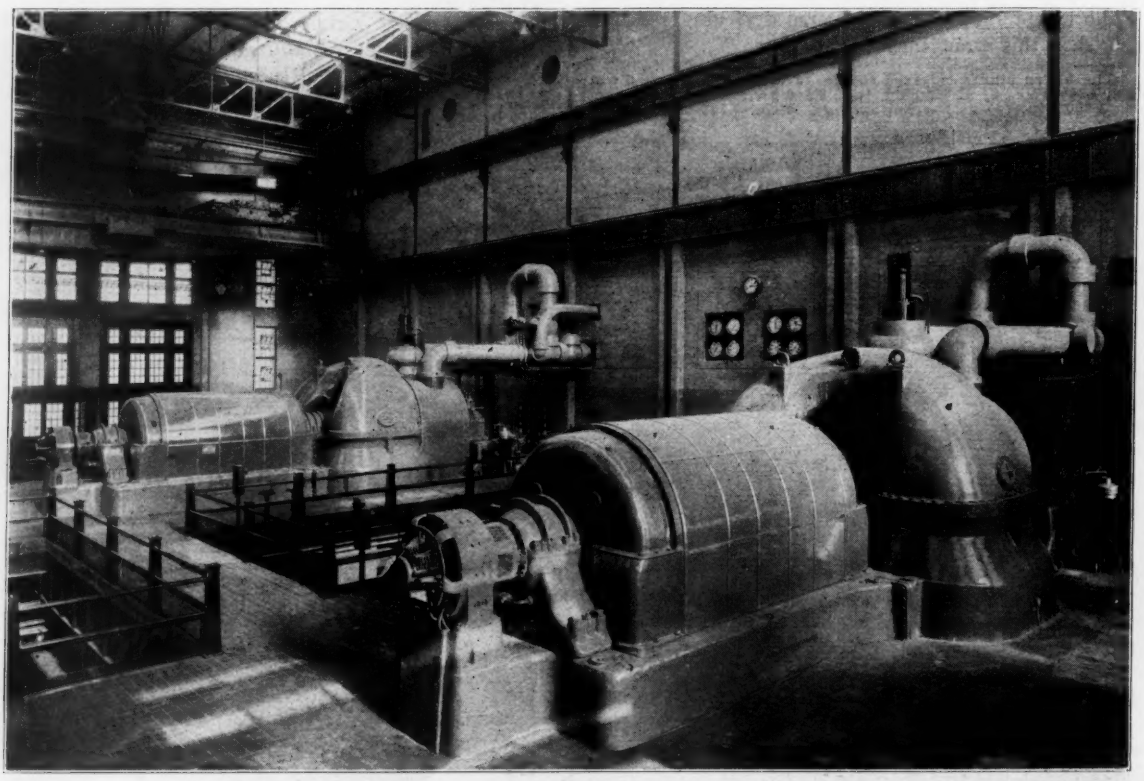


FIG. 5. TWO 40,000-KW. TURBO-GENERATORS NOW INSTALLED, SHOWING OIL PURIFIERS, GAGE BOARDS AND REHEAT CONNECTIONS

furnace with a low wall between them, giving a combined grate area of 356 sq. ft. The boilers supplying No. 2 unit are equipped with Babcock & Wilcox chain grate stokers. These stokers are divided through the middle, with separate motor drive for each half of the grate. The grate bars interlock, however, on this centre line and there is no brick wall dividing them, so that for all practical purposes they may be considered one continuous stoker across the width of the furnace.

Ash from these furnaces drops into steel, brick-lined ash hoppers, equipped with quenchers, located in the boiler room basement. From these it passes through clinker grinders into sluiceways in the basement floor, the same as at Philo, and is sluiced outside the boiler house to a well. From this well, it can be pumped to an ash storage pile or it can be removed from the well by a Brownhoist locomotive crane and loaded into railroad cars for disposal.

Flue gas from the boilers leaves the setting opposite the superheater, passes downward through an 8837 sq. ft. economizer, then makes a 180-deg. turn and passes up through a 10,291-sq. ft. tubular type air preheater to the induced draft fan. Each boiler is served by one induced draft fan rated at 108,000 cu. ft. per min., with duplex motor drive for flexibility. These motors are 2300-v. variable speed induction motors, one 125 hp. at 690 r.p.m., the other 250 hp. at 900 r.p.m., coupled to the fan shaft. This induced draft fan installation, as well as that of the forced blast fans, is similar in most details to that at Philo.

Air for forced blast for the stokers is taken from the upper part of the boiler house, near the ceiling, passes down through the air preheaters, which raise its temperature to about 205 deg. F. and is discharged by the forced blast fans into ducts leading to the stoker air compartments,

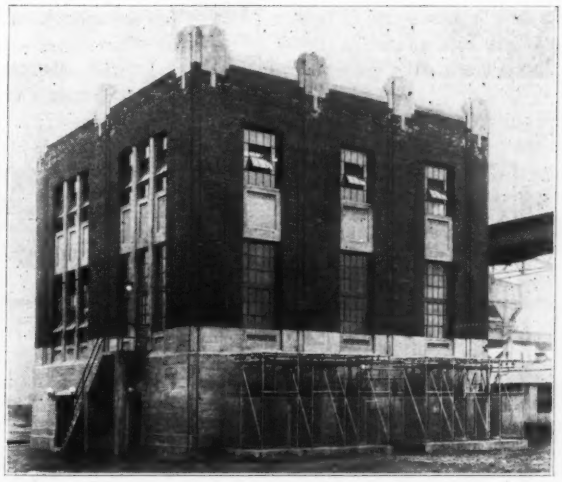


FIG. 6. MOTOR GENERATOR SETS IN THIS COAL HANDLING SUBSTATION FURNISH D. C. FOR COAL HANDLING MOTORS

average windbox pressures being 2.5 in. of water. Forced blast fans are of the radial flow type, one for each boiler, and are rated at 55,000 cu. ft. per min. at 3½ in. of water. These fans also have duplex motor drive, one motor being a constant speed, 2300-v., 75-hp. unit, the other a 125-hp. unit of the same characteristics.

Two steel stacks 155 ft. high are installed. One is 16 ft. in diameter, handling the gases from the boilers of No. 1 unit. The other, 22 ft. 6 in. in diameter, handles gases from the No. 2 battery and is designed large enough so that it will take care of the next unit of four boilers that will be added in the future.

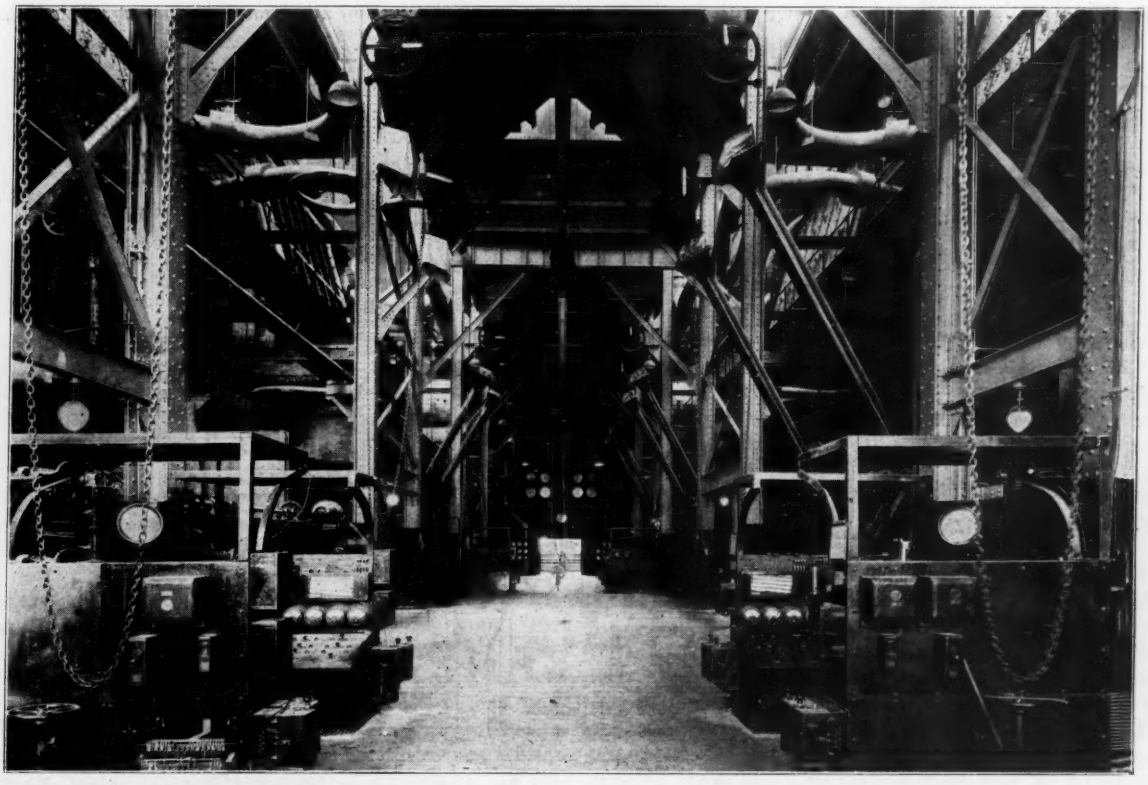


FIG. 7. BOILERS, CONTROL BOARDS AND STOKERS PRESENT ESSENTIALLY THE SAME APPEARANCE AS THOSE AT PHILO

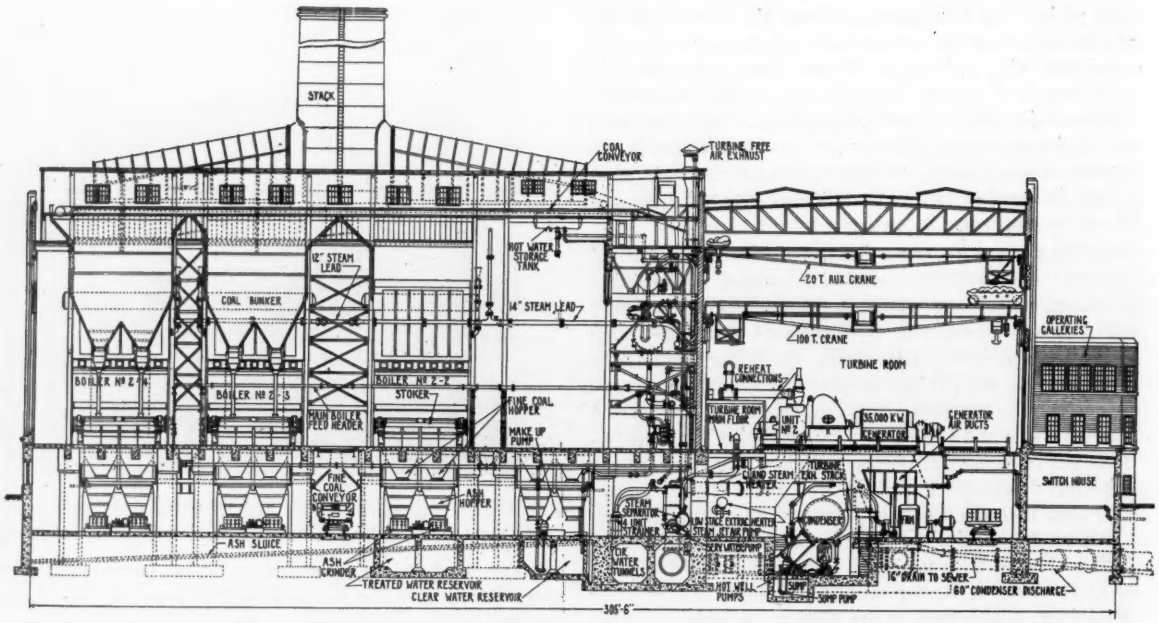


FIG. 8. PROPER LOCATION OF MAIN CONDENSER PERMITS ELIMINATION OF CONDENSER CIRCULATING PUMPS

Boiler feed water is supplied by condensate and make-up from shallow wells, but since this operation is somewhat different at Twin Branch from that at Philo and since it is connected with operation of the evaporators, generator air coolers and extraction heaters, it will be discussed in detail after describing the turbines.

These turbines, of which there are two in the initial installation, are of the same 40,000-kw. General Electric Co. design as those installed at Philo, with exactly the same design and operating conditions. The turbines shown in Fig. 5 are of the 19-stage, single cylinder type, operating at a throttle pressure of 600 lb. and an initial total temperature of 725 deg. The entire volume of steam is taken from the turbine at the 7th stage at 150 lb. gage pressure, reheated by the reheat boiler and returned to the 8th stage at 147 lb. pressure and 725 deg. total temperature. Provision is also made for bleeding from the 6th stage for jet air-pump operation and from the 12th and 16th stages

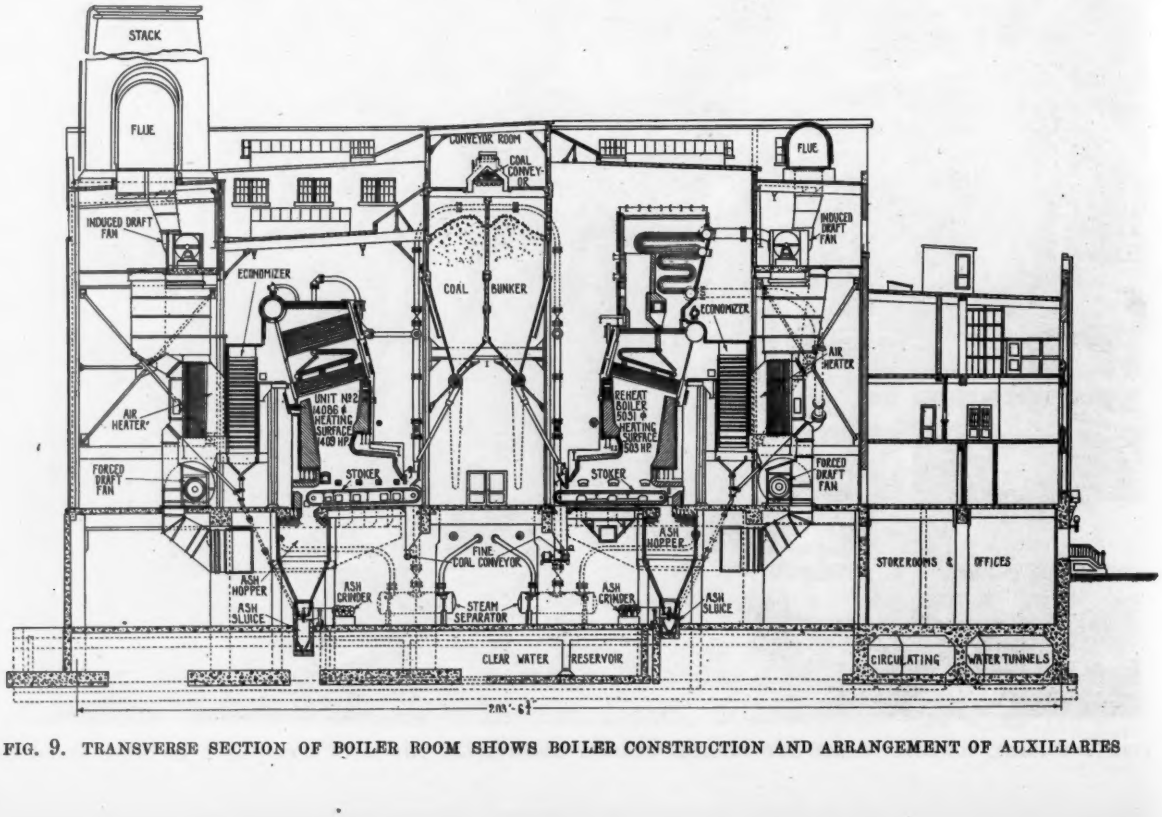


FIG. 9. TRANSVERSE SECTION OF BOILER ROOM SHOWS BOILER CONSTRUCTION AND ARRANGEMENT OF AUXILIARIES

for use in the various feed water heaters as will be described later. Each turbine has its own oil purifier of the centrifugal type.

Design Eliminates Condenser Circulating Pumps

From the 19th and last stage of the turbine, the steam passes to the horizontal, single pass condenser shown in Figs. 8, 11A and 11D, installed in the customary way immediately under the turbine. This condenser is entirely different from the vertical surface condensers used at Philo, has eliminated the elevator needed to serve such a well and has made some changes in design of intake and discharge tunnels. Sand pumps are not installed with these condenser units.

The above condensers, one of which is shown in Fig. 11D, are furnished by Wheeler Condenser & Engineering Co. Each one has a surface of 25,720 sq. ft. with provision for 30,030 sq. ft. This is a single pass condenser, the tubes being of Muntz metal 21 ft. 2½ in. long and varying in diameter from 1 to ¾ in.

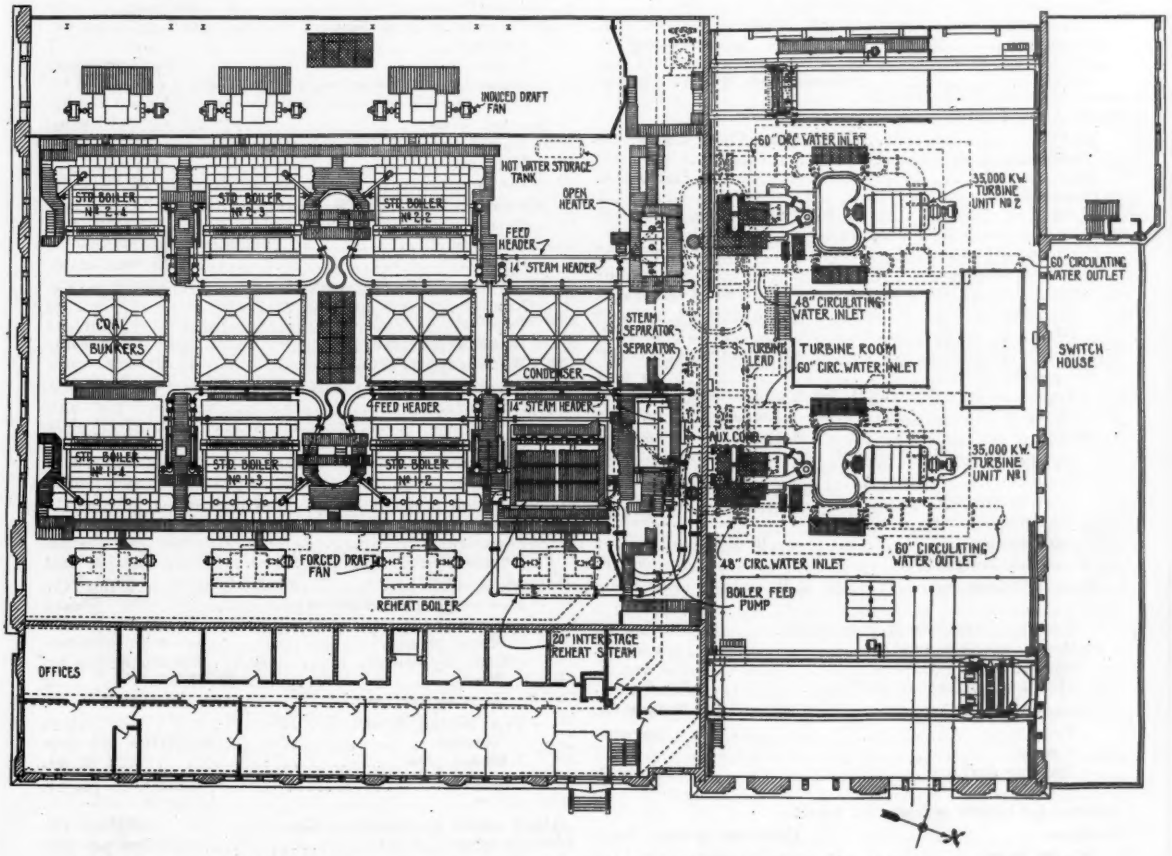


FIG. 10. EACH 40,000-KW. UNIT WILL BE SERVED BY FOUR BOILERS, THREE STANDARD AND ONE REHEAT, BATTERY NO. 2 BEING UNDER INSTALLATION

as the water conditions at Twin Branch were different. The principal feature of interest here is that no circulating pumps for condensing water are installed in the station. It will be remembered that at Philo the circulating pumps were used only about 2 or 3 mos. a year, thus saving materially in operating charges for the rest of the year. Twin Branch not only eliminates the operating charges for condenser circulating water, but also the fixed charges on initial investment for installing these pumps.

This result was attained by utilizing the 24-ft. head of water created by the dam, Fig. 3, at the existing hydroelectric plant in the St. Joseph River at this point. The top of this dam is at El. 716 and the tops of the condensers were set at this elevation, producing an adequate flow of circulating water. It is estimated that the natural flow of the river, regulated at this point by the dam, will prove sufficient to supply condensing water for the ultimate 240,000-kw. plant. This arrangement of condensers has obviated at Twin Branch the need of a deep condenser well,

The crib house is, of course, on the river bank, about 300 yd. from the power house, as shown in Fig. 12. It contains 5 traveling screens, driven by squirrel cage motors. From the crib house, the intake tunnel runs to the condenser pit, as shown in Fig. 8, and the water, after passing through the condenser, passes to a sealing well, just outside the boiler house and then through the main discharge tunnel, emptying into the river again about 1000 ft. below the dam.

Condensate from the hot wells is removed by the hot well pumps, which force it through the fin-type generator air coolers, shown in Fig. 8 and Fig. 11A, and then through the after condenser of the steam jet vacuum pump. From here it passes to the evaporator condenser, then in succession to the 16th stage extraction heater, the deaerator vapor condenser, the gland steam heater and finally to the open feed water heater. In the last named heater, steam extracted from the 12th turbine stage may be introduced if necessary.

The above arrangement of heaters is the same as that at Philo. The essential difference between the systems of the two plants, however, is that at Twin Branch it has not been found necessary to install water treatment apparatus for boiler feed make-up water, since the characteristics of the ground water used for this purpose are such that it is necessary only to distill it in the evaporators. The water to be evaporated for boiler feed make-up, together with all the ground water used about the station is taken from shallow wells by two 6-stage, motor-driven, deep well pumps, delivering 750 g.p.m. each against a head of 250 ft. During hot weather, part of this water is pumped as cooling water to the quadruple effect evaporator, which is rated at 40,000 lb. per hr. The distilled water is then pumped to one of the outside storage tanks, shown in the headpiece and in Fig. 12, outside the power house. These are 100,000 gal. tanks, supported on 100-ft. steel towers, one tank being used for distilled water and one for service water. A 200,000-gal. concrete storage tank is also provided in the boiler room basement floor, for storage of hot distilled water. From the storage tanks, the distilled water is pumped to the open feed water heater, where it mixes with

Principal Equipment at Twin Branch

Main Generating Units—
- Make ..... General Electric Co.
- Number 2
- Rating 40,000 kw. 95 per cent p.f., 11,000 v., 3 ph., 60 cyc.
- Steam temp. ..... 725 deg. F.
- Steam pres. at throttle ..... 600 lb. ga.
- Exciters ..... direct conn., 250 kw., 250 v.

Condensing Equipment—
- Make ..... Wheeler Cond. & Eng. Co.
- Number ..... 1 condenser per unit
- Type ..... Horizontal
- Passes 1
- Surface sq. ft. ..... 25,720 provision for 30,030
- Tubes ..... 1 in. to ¾ in. Muntz, 21 ft. 2½ in.
- Circulating pumps ..... None installed

Hot well pumps, No. ..... 2 per unit
- Type ..... Centrifugal
- Capacity ..... 700 g.p.m. each
- Head ..... 235 ft.
- Drive ..... 125 hp. squirrel cage motor

Air pumps, No. ..... 1 per unit
- Type ..... Steam jet, inter and after condensers
- Capacity ..... 48 c.f.m. at 29.5 in. vac.

Standard Boilers, make ..... Babcock & Wilcox Co.
- Number 6
- Type ..... cross drum
- Heating surface ..... 14,086 ft.
- Working pressure ..... 650 lb.
- Superheater ..... B. & W., convection
- Steam temperature ..... 725 deg. F.

Reheat Boilers, make ..... B. & W. special cross drum
- Number 1
- Heating surface, high pres. part ..... 5031 sq. ft.
- Pres., high pres. part ..... 650 lb. per sq. in.
- Steam temp., high pres. part ..... 725 deg. F.
- Steam temp., reheat portion ..... 725 deg. F.

Economizers, make ..... Babcock & Wilcox Co.
- Type ..... Duratex
- Number 7
- Heating surface ..... 8837 sq. ft.

Stokers for boilers serving No. 1 unit—
- Make ..... Combustion Eng. Corp.
- No. per boiler 2
- Type ..... Coxe, forced blast
- Effective area ..... 356 sq. ft.
- Drive ..... 3-hp. d.c., var. speed motors

Stokers for boilers serving No. 2 unit—
- Make ..... Babcock & Wilcox Co.
- No. per boiler 1
- Type ..... Chain grate, forced blast
- Effective area ..... 365 sq. ft.
- Drive ..... Two 3-hp. d.c. variable speed motors

Forced draft fans, make ..... Green Fuel Econ. Co.
- Number 7
- Type ..... Radial flow
- Capacity ..... 55,000 c.f.m. at 3½ in., 70,600 c.f.m. at 5 in.
- Drive ..... two a.c. motors, const. speed, 75 and 125 hp.

Air Heaters, make ..... Babcock & Wilcox Co.
- Type ..... Tubular
- Air Heating surface ..... 10,291 sq. ft. each

Induced draft fans, make ..... Buffalo Forge Co.
- Number 7
- Type ..... Straight blade
- Capacity ..... 108,000 c.f.m. at 4 in., 130,000 c.f.m. at 5 in.
- Drive ..... Two a.c. motors, variable speed, 125 and 250 hp.

Stacks, type ..... Steel
- Height above boiler room floor ..... 155 ft.
- Number 2
- Diameters ..... One 16 ft., one 22 ft. 6 in.

Air compressor, make ..... Worthington Pump & Mach. Corp.
- Capacity ..... 670 c.f.m.
- Pressure ..... 100 lb. per sq. in ga.
- Drive ..... 200 hp. syn. motor

Generator air coolers, make ..... General Elec. Co.
- Number for each machine 12
- Type ..... Surface
- Water supply, 6 units ..... Condensate
- Water supply, 6 units ..... Ground water

Generator ventilating fans, make ..... Green Fuel Econ. Co.
- Number ..... 2 per unit
- Type ..... Steel plate
- Capacity, each ..... 45,000 c.f.m.
- Pressure ..... 10 in. water
- Drive ..... 150 hp. squirrel cage motor

Turbine oil purifiers, make ..... DeLaval Steam Turbine Co.
- Type ..... Centrifugal
- Capacity ..... 200 gal. per hr.
- Number ..... One per unit

Heaters, make ..... Elliot Co.
- Low stage extraction, type ..... Closed
  - Number ..... One per unit
  - Steam pres. ..... 6 lb. absolute
  - Capacity, water ..... 300,000 lb. per hr.
  - Passes 3
  - Heating surface ..... 1770 sq. ft.
- Feed water, type ..... Open
  - Number ..... One per unit
  - Steam pres. ..... 3 lb. ga.
- Capacity ..... 300,000 lb. per hr.

Gland steam condensers, make ..... Elliott Co.
- Number ..... One per unit
- Type ..... Surface
- Steam pres. ..... Atmospheric
- Capacity, water ..... 250,000 lb. per hr.
- No. passes 3
- Heating surface ..... 1050 sq. ft.

Deaerators, make ..... Elliott Co.
- Number ..... One per unit
- Capacity ..... 300,000 lb. per hr.
- Air removal ..... Steam jet pumps

Evaporator, make ..... Wheeler Cond. & Eng. Co.
- Number 1
- Type ..... Quad. effect, film, reversing
- Capacity ..... 40,000 lb. per hr.
- Evaporator condenser, type ..... Surface
- No. passes 2
- Surface ..... 2250 sq. ft.

the condensate, the mixture then going to the deaerators, after which it is picked up by the boiler feed pumps and forced through the economizers into the boilers.

Four boiler feed pumps, of the same type and size as those at Philo, are installed at present to serve the two batteries of boilers. These are located on the main boiler room floor. There are two motor-driven and two turbine driven centrifugal pumps, one of each type being installed for each boiler battery. Motor driven pumps are 6-stage Cameron centrifugal, 750-g.p.m., 1750-r.p.m. units, designed for 650-lb. head; the other two are Bethlehem Weir turbine-driven centrifugal pumps, rated at 750 g.p.m. against a 650-lb. head.

As might be expected in plants of this type, the control equipment is arranged for the utmost convenience as well as efficiency of operation. In addition, recording instruments give all data necessary for making an accurate and continuous analysis of station performance. Control equipment at Twin Branch is in all essentials the same as that at Philo.

Control of boiler operation is almost entirely within the judgment of the fireman, S-C feed water regulators being

Principal Equipment at Twin Branch

Boiler feed pumps.....
..2 Weir type by Bethlehem Shipbuilding Corp., 750 g.p.m., 650 lb., ga., turbine drive. 2 Cameron, 6 stage, 750 g.p.m. 650 lb., 600 hp., phase-wound motor drive.

Boiler feed water regulators.....The "S-C" Regulator Mfg. Co.

Miscellaneous Pumps—

Heater drain, make..Worthington Pump & Mach. Corp.
Capacity.....80 g.p.m.
Head.....250 ft.
Drive.....20 hp. squirrel cage motor
Number 3

Make-up pumps, make.....Yeomans Bro. Co.
Number 2
Capacity.....100 g.p.m.
Head.....110 ft.
Drive.....15 hp. squirrel cage motors

Service pumps, make..Worthington Pump & Mach. Corp.
Type.....2 stage
Number 3
Capacity, each.....1500 g.p.m.
Head.....220 ft.
Drive.....150-hp. squirrel cage motors

Ground water supply pumps, make.American Well Wks.
Type.....6 stage, deep well
Number 2
Capacity, each .....750 g.p.m.
Head .....250 ft.
Drive.....100-hp. squirrel cage motors

Traveling screens, make.....Chain Belt Co.
Number 6
Number 5
Size.....7 ft. by 64 ft. 2 in.
Speed.....9 ft. per min.
Screen openings.....⅜ in. square
Driven by.....Two-speed, squirrel-cage, motors

Cranes, make....Whiting Corp. and The Morgan Eng. Co.
Use (Whiting).....Screen handling
Span.....24 ft. 7 in.
Capacity.....20 t.
Use (Morgan).....Turbine room
Span.....87 ft. 6 in.
Capacities.....100 t. and 10 t. hooks
Use (Morgan).....Turbine room
Span.....88 ft. 4 in.
Capacity.....20 t.
Motors.....All crane type

Bilge pumps, make.....Yeomans Bros. Co.
Type.....Vertical, submerged
Capacity.....Three 500 g.p.m.

Elevators, make.....Otis Elevator Co.
Type.....Push button
For office building, pass., capacity.....1500 lb.
For office building and plant, frt., capacity....5000 lb.

Insulation.....Johns-Manville, Inc.

Valves.....Crane Co., The Edward Valve & Mfg. Co., Chapman Valve Mfg. Co. and J. Hopkinson & Co., Ltd.

Piping.....Midwest, installed by Urbauer-Atwood Co.

Blowoff valves....Yarnall-Waring Co., Babcock & Wilcox (1 boiler) and J. Hopkinson & Co., Ltd. (blowoff cocks on 1 boiler).

Safety Valves.....Manning, Maxwell & Moore, Inc.

Ash Conveying Equipment—
Type.....Brownhoist Locomotive crane
Bucket capacity.....1 yard

Ash disposal pumps, make.....
.....American Manganese Steel Co.
Number 2
Type .....Centrifugal
Capacity.....1500 g.p.m.
Drive.....200-hp. squirrel cage motors

Clinker grinders.....Westinghouse E. & M. Co.

Crushers, make.....American Pulverizer Co.

Coal Spreaders—
Unit No. 1 boilers.....Universal Coal Spreader Co.
Unit No. 2 boilers.....Phillips Spout Swingers

Coal Dumping, Storage and Conveying System designed and installed by.....American Gas & Electric Co.

Miscellaneous Electrical Equipment—

Coal-handling Substation—
Number of units.....2
Type.....a.c., d.c. motor-generator
Capacity.....300 kw. each
Make.....General Electric Co.

Battery charger, make.....General Electric Co.
Type .....Motor-generator
Rating.....35 kw.

Storage battery, make.....Electric Storage Battery Co.
No. cells.....120
Rating.....50 amp., 8 hr. rate

Service Transformers, make.....General Electric Co.
Station service, No.....3
Connection .....Delta
Rating.....2500 kv.a.
Voltage.....11,000/2300 v.
Taps at.....11,550, 10,450 and 9900 v.
Cooling .....self

Distribution, number.....7
Make.....Westinghouse E. & M. Co.
Rating.....15,000 kv.a.
Phase .....Single
Voltage...11,000/132,000, with four 2½ per cent taps
Connections .....
..Low voltage delta, and high voltage y, grounded

Switchgear, make.....
General Electric Co. and Westinghouse E. & M. Co.

Disconnecting switches.....Delta Star Elec. Co.

Hydro-electric Plant—
Use.....Auxiliary house generator and feeder supply
Units 6
Capacity total.....7260 kw.
Voltage 2300

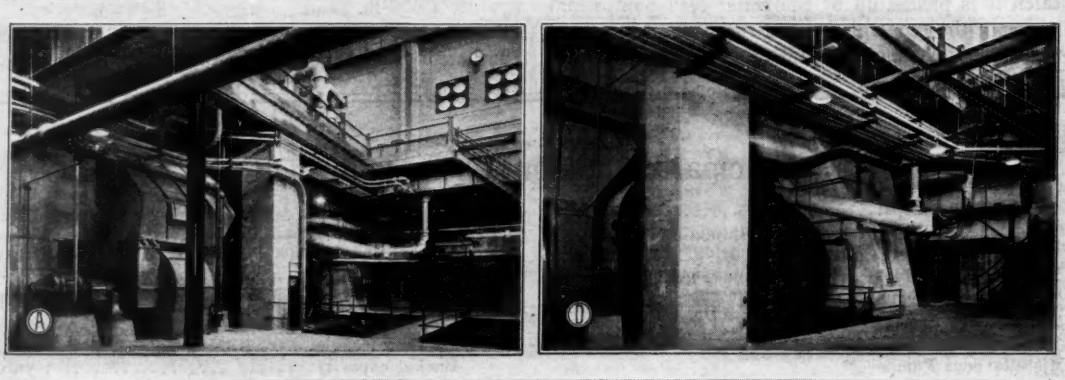
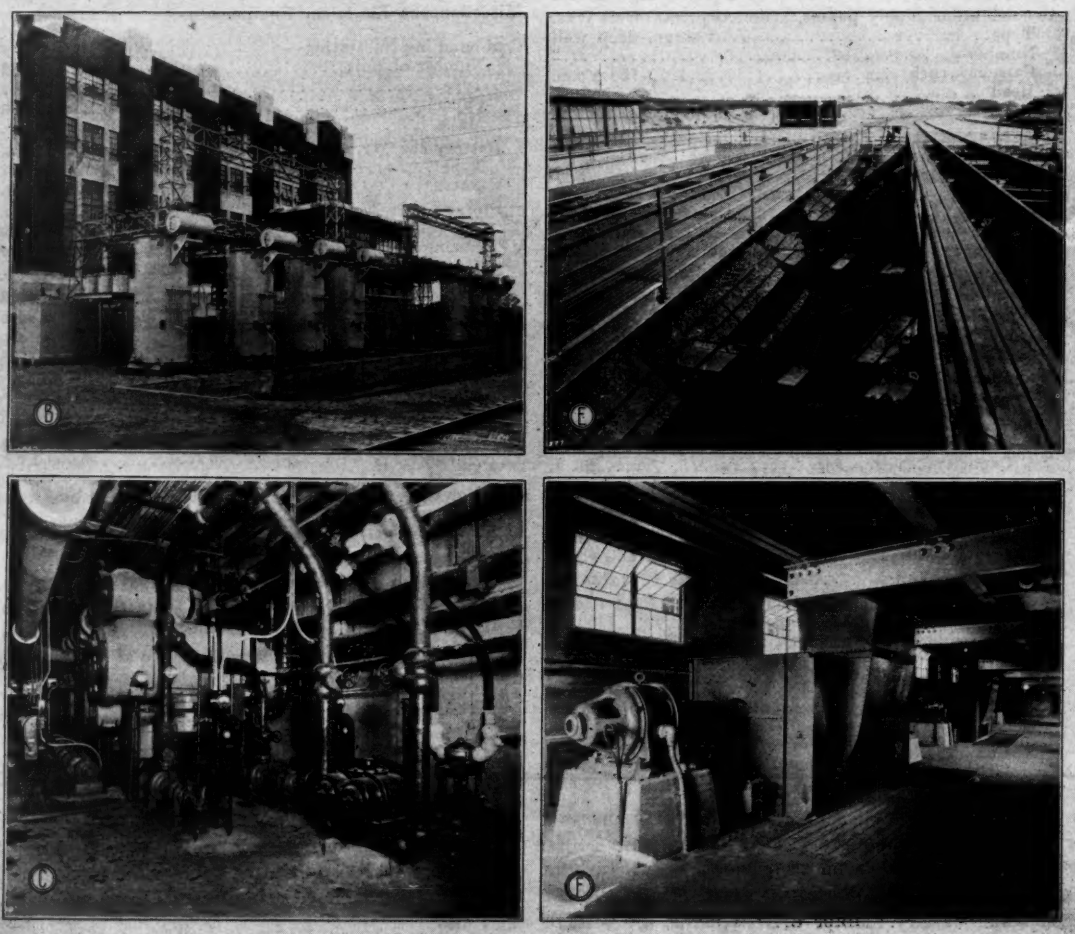


Fig. 11. Details of Equipment at Twin Branch

A—Generator ventilating fan, single pass horizontal surface condenser for No. 1 unit, with extraction heaters in background. B—Distribution transformers are outside north wall of main building. C—Quadruple effect evaporators are installed in boiler room basement. D—Condenser for No. 2 unit, with gland heater near wall (above) and 16th stage extraction heater just below it. E—Coal entering the storage yard is dumped into these pits. F—Variable speed A. C. motors of 125 and 250 hp. capacity form duplex drive for induced draft fans.



the only automatic equipment installed. Each fireman has charge of two boilers, his station being equipped with two control benches, located between the firing aisle just in front of and between the two boilers they control, as shown in Fig. 7.

On the wall between turbine and boiler rooms is installed a system of large indicating gages, showing present and expected load, boiler feed pressure, throttle pressure and first stage bowl pressure. These gages are of the double-faced, illuminated type and can be seen from the boiler room, turbine room and operating room above the switch house, as in Figs. 1, 5 and 7. A control and meter board at one end of the boiler house gives information of boiler performance and load conditions. On the wall in front of each turbine is a gage board of indicating and recording instruments, as shown in Fig. 5. Piping connections to the reheat boilers are a little different at the turbine end from those at Philo, as Fig. 5 shows, but the principle is just the same. A valved cross-over in those reheat connections is provided for by-passing the reheat boiler, in case it is necessary. Valves on the main steam header and reheat valves have push button control in the turbine room. Non-return valves are closed by push button control from the centralized control board in the boiler room office, but in order to open these valves the operator must use a button located near the valve. In case the emergency governor of the turbine trips out, due to the load of the turbo-generator unit being suddenly dropped, automatic equipment will close the main throttle valve, the controlling valve, and an intercepting valve between the reheat boiler and the turbine, at the same time opening air admission doors in the reheat section of the reheat boiler, preventing it from overheating. In addition, the fans are automatically switched to their smaller motors.

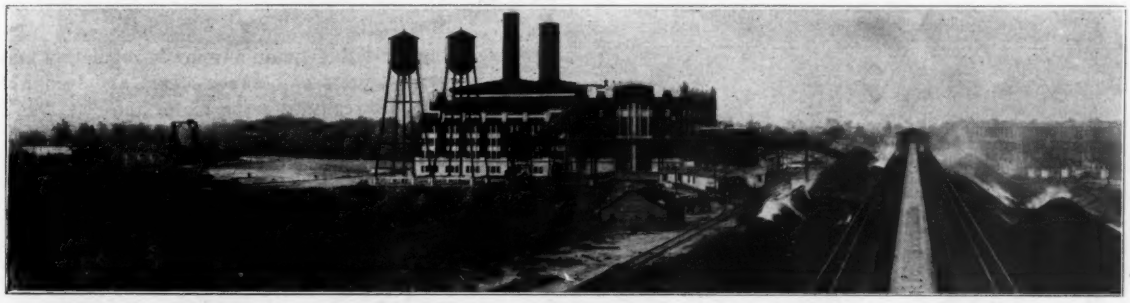


FIG. 12. COMPLETE TWIN BRANCH PLANT, WITH CRIB HOUSE AND HYDRO PLANT AT LEFT AND COAL STORAGE YARD IN FOREGROUND

Spare Parts May Be Exchanged With Philo in Emergency

For making routine repairs in the plant a machine shop is located at the east end of the turbine room between the level of the turbine room floor and the condenser and boiler room basement floors. The turbine room cranes, the lower of which has a capacity of 100 T. and the other of 20 T., as at Philo, serve the machine shop as well as the turbine room. Here also will be stored a spare turbine rotor and a spare transformer, also duplicates of the equipment used at Philo. At the latter station, it will be remembered, a complete spare generator is stored. Since the turbo-generators of both plants are exact duplicates, these parts can be exchanged between the two stations, in event of trouble with this equipment. This would make repairs possible on the generating units within a week or two, whereas, if the material had to be shipped from the factory, the time in transit would be much longer. Up to the present time, however, no trouble has occurred to bring these replacement parts into use.

The main control room and operating room of the station, Fig. 1, is above the switch house, as shown in Fig. 8. The operators thus have a full view of the turbine room on one side and of the 132-kv. switch yard on the other. The electrical system of Twin Branch is the same as that at Philo. There is no high tension bus system in the station itself, the switch house equipment being designed for 2300-v. Current is generated by the main units at 11,000-v.; the generator leads pass outside the station to the transformers shown in Fig. 11B, which raise the voltage to 132,000-v., and the power then goes to the high tension switch yard, Fig. 2. From this yard a transmission line leads to the 132,000-v. substation at South Bend, which at the present time connects with the rest of the transmission system of the American Gas & Electric Co. The old 25,000-kw. steam station at South Bend also connects with the system at this point. A transmission line leads from here to Lima, Ohio. Philo, through its various interconnections, feeds into the transmission system at one end and Twin Branch at the other, plants belonging to subsidiary companies being interconnected at various points.

For house service, the 11,000-v. generator leads are tapped ahead of the main circuit breakers and the house service is obtained from three 11000/2300-v. transformers. Practically all the auxiliaries in the plant, with the exception of two turbine-driven boiler feed pumps and the steam jet condenser vacuum pumps, are motor driven. Stoker and valve operating motors use d.c., power being furnished to them by motor-generator sets in the boiler room, as noted above. All other motors are of the squirrel cage and slip-ring induction motor types, many of them designed for full-voltage starting. A 250-v. storage battery, with a 35-kw. battery charging motor-generator set, is also installed.

Hydro Plant Serves as Floating House Generator

In connection with the auxiliary drive, the small hydro-electric plant on the river near the power house acts as a floating house generator, as mentioned above. It is connected to the auxiliary bus in such a way that in case a disturbance caused the auxiliary power from the service transformers to be interrupted, the hydro-electric plant would immediately assume this load and the auxiliaries could be operated. The advantage of this arrangement is obvious in first starting up the station or in starting up

after a complete shutdown of all units, which is, of course, only a remote possibility. Figure 3 shows the dam and hydro-electric plant at Twin Branch. The dam and power house are of concrete, the dam having 7 Taintor gates. Six water wheel generators are installed giving a total capacity of 7260-kw. and generating at 2300-v.

The power house control room is equipped with a General Electric Co. carrier current telephone transmitter used in conjunction with a carrier current communication system which is used over the entire transmission system.

Twin Branch Station was built for the Indiana & Michigan Electric Co., a subsidiary of the American Gas & Electric Co., of which R. E. Breed is chairman of the board, Geo. N. Tidd is president, F. A. Johnson is mechanical engineer and M. L. Sindeband is electrical engineer. Thos. F. English is vice-president and general manager of the Indiana & Michigan Electric Co., and Geo. W. Schmidt is superintendent of power at Twin Branch. The plant was designed by Sargent & Lundy, engineers, cooperating with the engineers of the American Gas & Electric Co.

Automatic Control at Cahokia

MOST OF THE AUXILIARIES AT CAHOKIA ARE MOTOR-DRIVEN AND EQUIPPED WITH AUTOMATIC CONTROL. BY H. T. LANGE*

POWER PLANTS which in past years contained little motor-driven apparatus now take advantage of heretofore unappreciated economies by employing motor-driven auxiliaries wherever possible. This condition, coupled with the enormous size and complexity of modern stations, has demanded automatic control. At Cahokia, the new 350,000-kw. power station of the Union Electric Light and Power Co. of St. Louis, all of the auxiliaries are motor driven except a boiler feed pump and a combination turbo motor driven reserve exciter.†

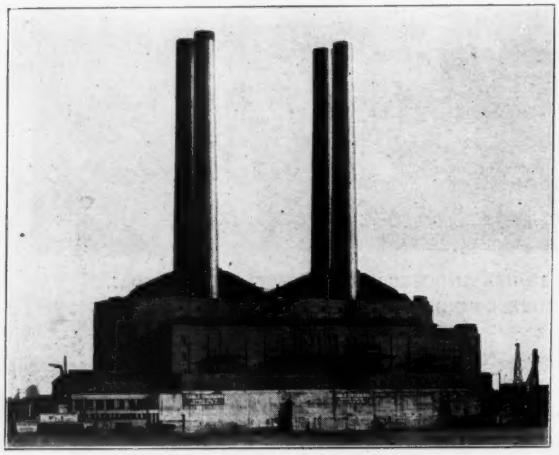


FIG. 1. LOOKING FROM THE MISSISSIPPI RIVER AT THE FIRST TWO SECTIONS OF CAHOKIA

Power is supplied from the 2300-v. house turbine either directly at 2300 v. or at 440 v. through step down transformers. About 90 per cent of the motors are automatically controlled by push-button stations or by float, pressure, vacuum, or other auxiliary switches. The remainder, mostly small, are hand controlled. The essential auxiliaries consist of circulating pumps, condensate pumps, vacuum pumps, boiler-feed pumps, air compressors, fans and screw conveyor stokers for the powdered fuel.

Cahokia pumps more water than the entire city of St. Louis consumes. Two 250-hp. slip-ring motors are used for each 35,000-kw. turbine generator, and control is provided in the form of motor-driven drum controllers, feeder panels and push-button stations.

Of particular interest is the method of boiler feeding. Up to the present time, seven centrifugal boiler feed pumps have been installed. Three of these are driven by 300 hp. motors, two by 375 hp. motors and two by 500 hp. motors, all of the slip-ring type and made by the General Electric Co.

Seven Ruggles-Klingemann automatic regulators maintain a differential pressure between steam and feed water of about 40 lb. by regulating the motor speeds. This assures a uniform water feed and is done by connecting a pressure-operated piston to a drum controller, thus cutting in and out secondary resistance. On the four larger units, contactor panels are included which are operated from the controller and short-cut the last three blocks of resistance. This was done to balance the rotor current on the last three steps. (The unbalance of large wound rotor motors not so provided is noticed on the house turbine voltage.)

Cahokia is interesting for many reasons, chief of which is that it was one of the first stations to use powdered fuel. The method of firing consists of conveying the powdered coal from hoppers by means of screw conveyors to a manifold where it is mixed with air and blown into the furnaces. Bailey regulators control the firing, screw conveyors carry the coal to each boiler and motor-driven fans of 100 hp. capacity supply the primary (about 15 per cent of the total) air used in combustion. The remainder of the air used enters the furnace through the side wall openings.

To prepare the powdered fuel, a complete coal plant has been provided which contains most of the miscellaneous auxiliaries. These include coal crushers, pulverizers, conveyors and driers. The remainder of the miscellaneous auxiliaries are motor generators, motor operated valves, service pumps and numerous small units such as fans and motor-operated doors.

Coal is handled a car at a time by a motor-operated car dumper which inverts the track and car as a unit and empties it into a motor-driven conveyor, 50 T. at a time. The coal is then crushed by crushers (driven by hand controlled slip-ring motors) and carried to the driers where hot gases, bypassed from the boiler uptake, are blown through the coal. The drier fans range in size from 100 to 150 hp. and are driven by squirrel-cage motors and controlled by automatic compensators.

The coal is then pulverized in Raymond mills—an example of automatic control in successful operation under unfavorable conditions. Located in odd corners of the coal plant, totally enclosed, 2300 v. compensators control 200 hp. squirrel-cage motors, themselves totally enclosed and ventilated. At one point in the plant a control panel

*General Electric Co. St. Louis, Mo.

†This station was fully described in the April 1st, 1924, issue of Power Plant Engineering.

Views at Cahokia Showing Features of Automatic Control

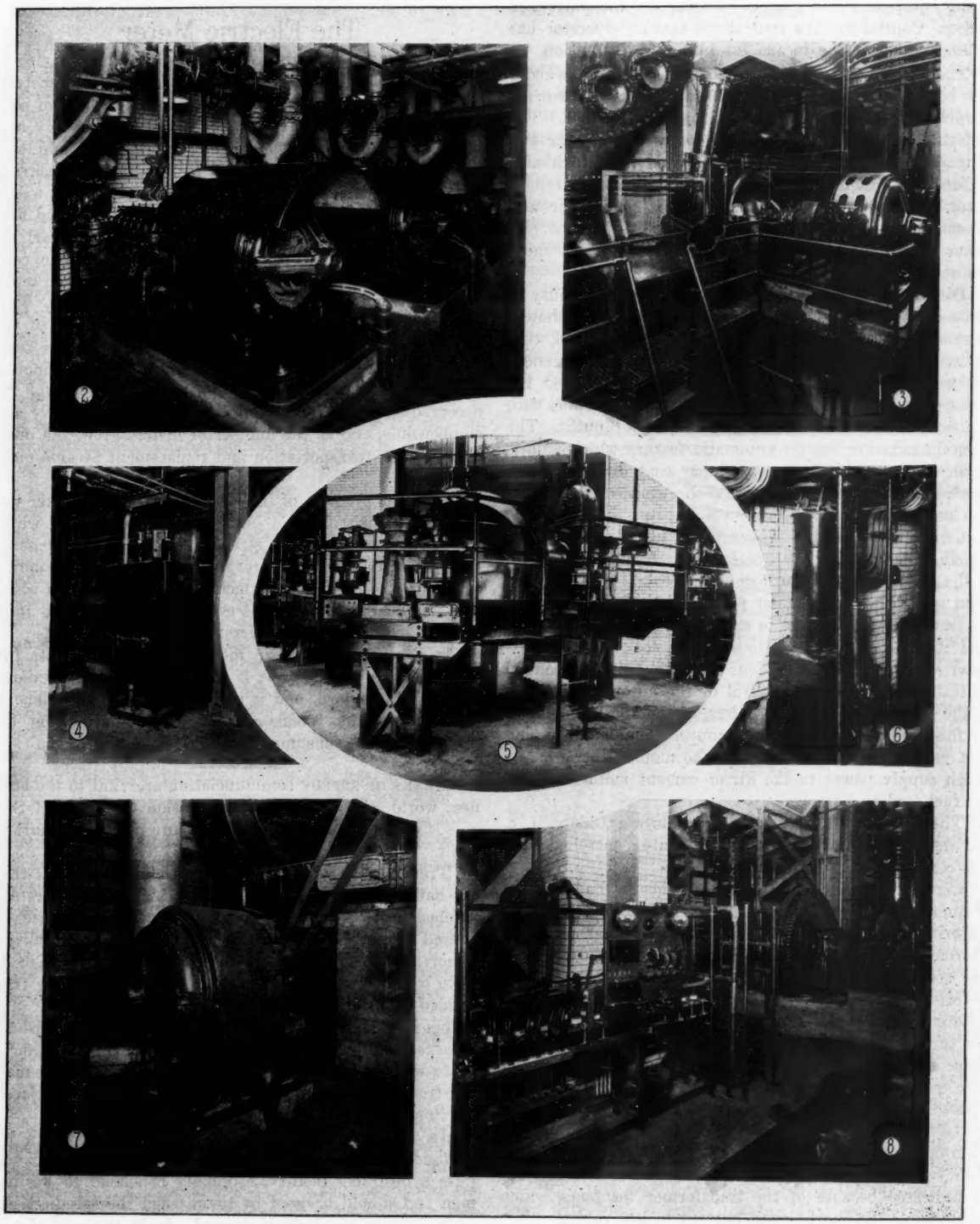


Fig. 2. Three 300 hp. slip ring feed pump motors controlled automatically by equipment shown in Fig. 6. Fig. 3. One of the 250 hp. slip ring motors driving circulating pumps for the 35,000 kw. turbines. These are controlled by push buttons operated oil circuit breaker and motor operated controller shown in Fig. 4. Fig. 4. Two 2300-v. control panels on 100-kw. motor generator sets. Fig. 5. Five G. E. motors on gate valves controlled by automatic starters and push buttons. Fig. 6. G. E. drum controllers actuated by Ruggles-Klingemann pressure regulator on 300 hp. slip ring motors on feed pumps. Fig. 7. 200-hp. enclosed ventilated squirrel cage motor on Raymond coal pulverizing mill. Fig. 8. Starting panel controlling 400-hp. synchronous motor

is located which contains thermometers for recording temperatures of coal in the hoppers, scales for weighing the pulverizer output, control of air valves for coal conveying equipment and control switches for the pulverizer motors. Control is thus centralized and the operator has at his finger tips the means for intelligent operation.

The coal is transported from the mills to the bins above each boiler by compressed air at 100 lb. pressure. Four air compressors have been installed for this purpose. The first three were belt-driven units and within a year two 15-in. belts have broken. For this reason the fourth unit is direct connected. It is a 400-hp., 2300-v. synchronous motor directly connected to a Sullivan compressor and automatically controlled. Push button control is used. By means of this compressed air the pulverized coal is "shot" almost the entire length of the two sections.

Direct current is employed where great flexibility is necessary and is supplied by motor generators. Although these sets are very infrequently started and stopped, centralized control is desirable and, therefore, automatic starting was provided. Automatic compensators control the motor generators which are arranged to run in parallel with a three-unit (turbine, motor and generator) outfit. The latter installation has an automatic feature which admits steam to the turbine upon a 10 per cent drop in motor speed, the set being already at the slip speed of the induction motor.

Centralized control has been provided for the coal pulverizing plant. This feature has also been incorporated in the boiler house in the form of a central control room from which the entire boiler plant can be shut down.

In case of an accident to any boiler or a sudden loss of load it will be imperative to stop the coal, air and feed water supply. This can be done instantly from the central control room by remote control of the automatic starters of the screw conveyor fuel feeders, of the 100-hp. primary air fans and of the boiler feed pumps. Complete a. c. and d. c. control is also provided for the motor generator sets which supply power to the direct current motors driving the fuel feeders.

The first section of the plant employs a 1380-v. a. c. starting bus (described later) which is also controlled from this central room.

Centralized control is employed further in the operation of numerous valves for steam, water and air control. The majority are motor-operated and employ either direct or alternating current drives. Some are solenoid-operated and some are air-operated, solenoid-controlled.

Motors controlled by either magnetic, or magnetic reversing switches operate the huge 6 by 8 ft. gate valve in the tunnels which carry the condenser circulating water. Since all of the valve motors must be reversed, those fitted with magnetic switches are also supplied with double throw enclosed hand-operated switches.

In general, all of the 2300-v. starters are protected from opening short circuits by oil circuit-breakers on individual feeder panels. The lower voltage starters are not so protected because of the transformer reactance which would limit the short-circuit current to low values.

The starting of 2300-v. squirrel-cage motors was originally effected by connecting them first to a half voltage bus and then transferring them by a time or transfer relay to full voltage. This scheme was simple, but it lacked the flexibility necessary for starting a variety of loads. The starting voltage was subsequently raised to 1380 with much better results. This method has been abandoned in the second section of the plant, and it appears that from now on control will be provided in the form of individual starters.

The Electric Meter

IN THE CITY of New York and its immediate environs, there are probably no less than two million electric meters. These meters are among the most important points of contact between the utilities supplying electrical energy and the millions of people using this energy for light and power. The first meter ever used for accurately measuring electric current as supplied from a central station was a chemical device, developed by Thomas A. Edison and first introduced among the customers of his famous Pearl St. Station. Each meter contained several electrolytic cells through which flowed approximately one one-thousandth of the current passing over the service at the time. This current caused a decomposition of the zinc plates of the cells and the weight of the metal decomposed was the basis for determining the amount of current used. The principal defect of this meter was the necessity for replacing the decomposed plates each month. The cells were heavy and cumbersome, and as the number of meters grew, the question of their transportation and replacement became quite serious.

With the progress of the electrical art a new meter was developed consisting of a small motor, the speed of which was in proportion to the strength of the current passing through it and which, in revolving, caused corresponding action on a series of gears attached to the dial fingers which one sees behind the glass of every meter and which indicate the exact amount of current used.

In a sense the modern meter resembles the best full jeweled watch or clock. It is manufactured in accordance with rigid standards and is carefully tested in the laboratory and testing rooms and, after installation, on the premises of the consumer.

MEANS OF SPEEDY communciation are vital to the business world, and the recent installation of Air Mail Service is a useful and important measure of postal improvement.

Transmission of mails by air is effected in less than one-half the time required by train. Air Mail letters dispatched from New York today in the afternoon are delivered at their address in Chicago by first carrier delivery tomorrow morning; or, if forwarded from Chicago by train to other points, will move by the first morning train instead of by a late evening train. The delivery of such letters in postal territory served from Chicago will usually be expedited by some 12 hours. A similar gain in time is made with respect to other Air Mail stations where mails are transferred to railroads for distribution in adjacent territory.

In business transactions where time is of much importance, the Air Mail Service is of great value. It supplies a desirable facility, especially beneficial to business men and should be used by them when the speediest possible delivery of letters is desired. As in the case of telegrams, it is wise, however, to send duplicates by fast regular mail.

INTERIORS OF FUEL OIL heaters should be cleaned at least twice a year because the coils become coated with an asphaltum deposit which seriously interferes with the transmission of the heat from the steam to the oil.

High Steam Pressures and Temperatures*

HIGH STEAM PRESSURES AND TEMPERATURES BRING GREATER ECONOMY BUT LIMITS ARE FIXED BY THE PROPERTIES OF MATERIALS AVAILABLE

DURING THE past year the problem of higher steam pressures and temperatures has received more intensive study and development than during any similar period in its past history. Two plants operating at 550 lb. per sq. in. pressure and 700 deg. F. have gone into operation, others now in the course of construction or design, and one 1200 lb. per sq. in. plant will go into operation in a short time.

These plants do not, however, represent anything radically different from the various schemes and combinations previously discussed from a theoretical standpoint or from a laboratory or limited operating experience. They represent, rather, the actual accomplishment in fact of the theoretical possibilities aimed at by the designing engineer.

In reviewing the past year, therefore, we find it one of active constructive work embodying the latest design developments, but with no very new or radical changes. It will be interesting to note what the actual accomplishment in operation of this latest step forward may be, and what changes, if any, may be advisable.

In a report by Professor Christie, discussion of "Higher pressures or Higher temperatures" analyzes the problem from a somewhat different viewpoint and presents some interesting conclusions. His 400 lb. per. sq. in. high temperature plant would evidently possess a somewhat greater degree of flexibility under varying load conditions than the higher pressure plants, due to the larger amount of heat stored in the water in the boilers and economizers.

It is well to remember, however, that these high pressure plants (above 425 lb.) are strictly base load plants, that they embody complications in equipment and operation which are relatively untried, and that the boilers have less heat storage capacity than the lower pressure boilers. The high pressure boilers are less adapted for carrying variable loads, even requiring an accumulator for heat storage under certain conditions, and demand a much quicker method of transferring heat units from the coal to the steam, to take care of load increases, and conversely a quicker method of stopping combustion if the unit loses all or a large part of its load.

It is encouraging to note that the reports coming in from the higher pressure plants indicate little, if any trouble which can be directly ascribed to higher pressures. The designers and manufacturers of equipment have evidently given the matter careful consideration in all its details, and a large measure of success can be confidently expected.

HIGH PRESSURES OR HIGH TEMPERATURES

The possibilities of plants operating with high steam pressures were presented in a comprehensive paper on High Pressure, Reheating and Regenerating for Steam Power Plants by C. F. Hirshfeld and F. O. Ellenwood before the A. S. M. E. in 1923.† Their studies covered the performance of steam plants with an initial total steam temperature of 700 deg. F. and with pressures ranging from 200 lb. to 1200 lb. per sq. in. abs. The final curves presented in their paper indicate that the B.t.u. per kw-hr. decrease with increasing pressure up to 1200 lb. abs. for power plants operating on either the Rankine or regenerative cycles.

In their paper on High Steam Pressures or High Temperatures, referred to previously, Christie and Turnbull, Jr., point out the difficulty of building equipment for 1200 lb. pressures and also the operating difficulties, at the same time showing that under this pressure no parts are above 700 deg. F. For this temperature materials are available which can be fabricated into the desired parts without unusual difficulty.

In the past station economy has been improved by increased steam temperatures as well as by increased steam pressures. Steam temperatures have increased from 500 deg. to 700 deg., the latter being chosen simply because the materials at hand do not permit the use of temperatures very much in excess of 700 deg. The only parts subject

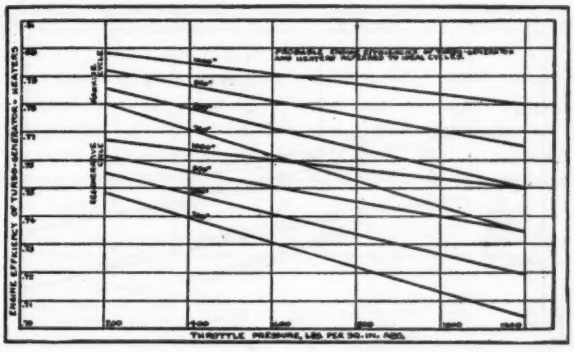


FIG. 1. ENGINE EFFICIENCIES OF TURBO-GENERATOR AND HEATERS

to the effects of high temperature are the superheater and its fittings, the steam piping, valves, drips, etc., and the high pressure section of the turbine. The remainder of the plant equipment would be that usually furnished for the pressure selected. If the B.t.u. per kw-hr. of the plant can be decreased by increasing the steam temperature above 700 deg. F. the boiler and condenser units will be decreased in size and hence in cost, while the only increase in cost will be for those parts already enumerated with which the highly superheated steam comes in contact. These parts form a small portion of the plant and their proportionate cost is not great. If such parts could be secured at a reasonable price, there are reasons to believe that a plant with high superheat and moderate pressure would cost less than a high pressure plant for the same station economy. The turbines with the higher steam temperatures would have a greater part of the expansion in the superheat region and hence less in the saturated state than with high pressure plants. This would result in a more economical turbine. This study was undertaken to find out the possibilities of higher steam temperatures and moderate pressures.

No materials are in use at the present time in this country in excess of 750 deg. total steam temperature in central stations. Certain parts have been subject to temperatures of 1000 deg. in the oil industry. New alloys

*Abstracted from a recent report of the Prime Movers Committe of the N. E. L. A.

†Abstracted in Power Plant Engineering, December 15, 1923.

such as Everbrite metal and others are being developed which can safely be used up to 1000 deg. Although it may not be possible at present to construct a 1000 deg. steam plant with full assurance of its operating success, it is very probable that satisfactory materials will be available in the near future if the demand for such warrants their development.

The studies presented by Prof. Christie and D. C. Turnbull, Jr. are too extended to admit of detailed treatment here. They indicate, however, that considerable gains are possible by the use of high steam temperatures at moderate pressures and this should stimulate development of metals for high temperature service. The conclusions reached from their studies indicate that for the Rankine cycle, the 400 lb. abs. plant with steam temperature of 825 deg. F. or higher is more efficient than even the 1200 lb. 700 deg. plant on this cycle. This is indicated in Fig. 2 where the variation of B.t.u. per kw-hr. with initial throttle temperatures and 400 lb. throttle pressure is shown. The B.t.u. per kw-hr. at various pressures as found by Hirshfeld and Ellenwood are also shown in this figure by the dotted lines. The 400 lb. abs., 1000 deg. F. plant on

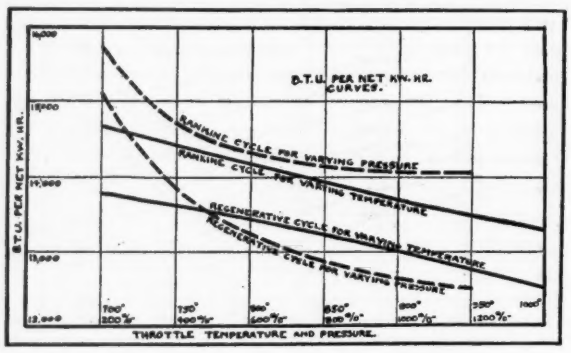

B.T.U. PER NET KW. HR. CURVES.
RANKINE CYCLE FOR VARYING PRESSURE
RANKINE CYCLE FOR VARYING TEMPERATURE
REGENERATIVE CYCLE FOR VARYING TEMPERATURE
REGENERATIVE CYCLE FOR VARYING PRESSURE
B.T.U. PER NET KW. HR.
THROTTLE TEMPERATURE AND PRESSURE.

FIG. 2. VARIATION IN B.T.U. PER NET KW-HR.

the regenerative cycle equals the performance of the 1200 lb. abs., 700 deg. F. station. If the high temperature plants had been figured for bleeding in the superheat region to give the same feed water temperature of 252 deg. F. as in the 400 lb. 700 deg. F. plant, there would have been a further decrease in B.t.u. per kw-hr. and the curves would have favored high superheat still more. These curves indicate that the 600 lb. abs. 700 deg. F. station has the same performance as the 400 lb. 850 deg. plant. Steam temperatures of 850 deg. F. are said to have already been used in Europe on steam turbines.

A study of the data presented indicates that many assumptions have had to be made, several of which may be open to question, as for instance, the efficiencies shown in Fig. 1, the methods of finding the feed water temperature in the actual plant, etc.

On the basis of these assumptions this study indicates that high plant efficiencies may be obtained with high steam temperatures at moderate pressures. The gains compare so favorably with those obtained with plants using high pressures that further development of materials for high steam temperatures is fully warranted. It also seems probable that the use of such material in a plant of moderate pressure will involve a smaller investment than would be needed for a high pressure plant of equal economy on account of the smaller amount of equipment that must be changed to use the high temperature steam. The results indicated by this study should encourage attempts to use still higher initial steam temperatures."

In discussing Prof. Christie's paper, A. E. White, Prof. of Metallurgical Engineering, University of Michigan, cited a paper by A. L. Mellanby and Kerr, read at Newcastle-on-Tyne, in which the authors considered the strength of the material at high temperatures to be the limiting factor on temperature. They venture the opinion that 900 deg. F. represents the steam plant limit. On the basis of available tests, the authors believe that chrome nickel steels are now available that have "creep limits" under high stress between 900 and 1000 deg. F.

Manufacturers' Statement

In the manufacturers' statements listed in the bulletin, Babcock & Wilcox Co. refer briefly to the 1200 lb. installations at the Weymouth (now the Edgar station) station of the Edison Electric Illuminating Co. of Boston, and at the Bridgeport works of the Consolidated Safety Valve Co. A number of B. & W. boilers for 650 lb. working pressure with reheater units have been installed.

Statement by the General Electric Company

Two General Electric turbines designed for steam conditions of 550 lb. gage, 725 deg. F. total temperature have been placed in successful commercial service since the 1923-1924 report was published.

The first 40,000-kw. unit for these conditions installed in the Philo Station of the American Gas and Electric Company was placed in Commercial service September 22, 1924.

The 60,000-kw. cross-compound unit installed by the General Electric Company in the Crawford Avenue Station of the Commonwealth Edison Company was placed in commercial service November 14, 1924.

The designing, manufacturing, erecting, and placing in commercial service of this large unit of an entirely new type in nineteen months is a very gratifying achievement, and will no doubt greatly reassure designers of new central stations, where, in the interest of economy and reliability, turbines of a new type are on order or under consideration.

The turbine designed for operation at steam pressures of 1000-1200 lb. for the Edgar Station of the Edison Electric Illuminating Company of Boston, has been installed.

Statement by the Heine Boiler Company

The highest pressure central station plant which the Heine Boiler Co. has installed was that furnished during the year to the Tri-Cities Plant of the United Light and Power Co., at Iowana, Iowa.

The installation consists of four cross-baffled cross-drum type boilers built for an operating pressure of 440 lb. per sq. in. A superheating equipment delivers steam at a temperature of 700 deg. F.

Designs have been made and a number of boilers offered for considerably higher pressure than this, but up to this writing none have been installed in central station plants above the 440 lb. working pressure mentioned above.

In a few isolated cases, however, boilers have been installed for higher pressures than this for industrial purposes, and a number of 500 lb. pressure boilers as long ago as 1897 were installed.

The statement of the Superheater Co. was largely an abstract of a paper by B. N. Broido presented before the A. S. M. E. which discussed recent developments in the use of high pressure and superheated steam. Developments

in apparatus for storing heat are discussed, trend in superheater design, methods of construction, etc. In superheater construction the elements of the more recent designs are long enough to supply superheat with high steam velocity. This was made possible by joining two or more pipes and making them continuous by means of the forged return bends, which are made by a special forge-welded process out of the metal of the tube without the use of electrical or other autogenous welding. Figure 3 shows a number of these units clamped to the headers. These bends also have the advantage that the metal is thickened at the ends of the element, the end itself being actually stronger than the body of the pipe. The sharp return bend breaks up any slugs of water which may enter into the superheater units, and insures that no water can be carried over to the main line beyond the superheater. This is particularly important for the present large modern boilers with large over-ratings.

Units and Header Joints

Due to the fact that the surfaces of a superheater are exposed to high temperature gases, and depend for their cooling upon the flow of steam, internal stresses are occasioned in the superheater structure. This is aggravated by the fact that steam becomes a less ready absorbent of heat as it becomes superheated. No matter how properly a superheater may be designed, its service is always more severe and more apt to cause disturbances in operation than is the case of boiler design. This applies to any superheater, particularly, however, to those for modern boilers designed for high pressure and high temperature. An up-to-date superheater, adaptable to the present and near future requirements of pressures and temperatures, must be so located that it is easily accessible so that it can be adjusted or inspected, and boiler operation resumed in a minimum time and at a minimum cost.

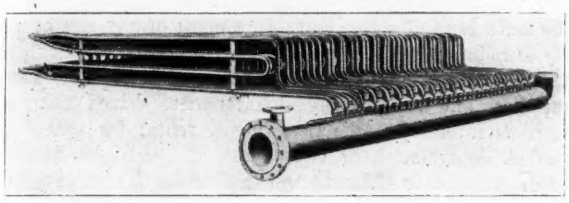


FIG. 3. SUPERHEATER WITH FORGED RETURN BENDS.

For a modern superheater it is extremely important that all parts are accessible for inspection, and those parts which by any chance may be subject to leakage of steam must be within convenient reach for correction or replacement.

The headers and joints must be located outside of the boiler so that they can be inspected without entering the setting. The bolt and clamp joint is applied. When necessary a unit can be removed in a very short time, and without entering the boiler setting; thereby avoiding the necessity of cooling off the boiler and then firing up again.

Statement by the Westinghouse Electric and Manufacturing Company

Turbines now operating or about to be installed for use with high pressure steam should make the coming year one productive of operating data that will permit a more accurate appraisal of the economic advantages of steam pressures above 400 lb. per sq. in. than is possible at present. Indications point to substantial practical gains in economy from a gradual trend to higher pressure. Pressures of 300 to 400 lb. per sq. in. are considered by this company as within the range of established practice. Turbines operating on steam within this range of pressure and a total temperature around 700 deg. F. have given no trouble in any way assignable to steam conditions and have shown efficiencies and economic advantages over turbines operating on lower steam pressures in agreement with calculated estimates. This company is prepared to build turbines for steam pressures as high as other power station equipment will permit. In view of the present status of information on the influence of temperatures on operation, it recommends that the total temperature at the turbine throttle be limited to 700 or 750 deg. F.

Standard for Steam Costs Needed

Cost Accounting of Both Live and Exhaust Steam. Need for Comparison in Industrial Plants. By W. J. Risley, Jr.

RECENTLY POWER PLANT journals have been devoting more space to the discussion and comparison of power plant costs in industrial establishments. This is encouraging and may lead to the same beneficial results that have been experienced in other industries where cost comparisons have been started. Iron foundries began an organized collection of cost data, and it was soon found that nearly every member of the industry was able to draw some valuable lessons from the results of the studies, to correct wasteful practices, to stop unsuspected leaks, and sometimes to change the net result of the ledger from red figures to black.

Paper industries, small print shops, and many others have derived similar benefits from cost comparisons and from the development of standard methods of cost accounting. We now have a standard method of testing a boiler and of calculating the results of the test; this insures us that test results are somewhere nearly comparable. But we don't have a standard method of finding out how much it costs to make a thousand pounds of steam, or a kilowatt-hour of current; and until we do, the comparison of power plant costs for industrial plants can be little more than general.

With the central station, or with any other plant making power alone the problem is not so difficult. All costs are applied to one end—the delivery of current to the bus bars. There may be differences of opinion on fixed charges—on the rate of depreciation, or on obsolescence charges, but these have no vital effect on the result. With the industrial plant, however, there is almost invariably a heating problem, and this gives rise to the question: What is exhaust steam worth?

Basis of Exhaust Steam Value Suggested

There has always been a considerable amount of discussion on this subject, but I do not recall having read a clearer outline of the various possible methods of determining the value of exhaust steam than that given by Tyler Fuwa in the July 28, 1924 issue of Chemical and Metallurgical Engineering. He points out that evaluation may be made on the basis of—(1)—Available power; (2)—Available heat; (3)—Arbitrary basis, combining the factors of available power and available heat; and (4)—Purchase price from an external source.

If we assume an initial steam condition of 175 lb. gage and 100 deg. superheat, non-condensing compound Corliss engines and exhaust at one lb. gage into the heating system when required, or to the atmosphere when not needed in the heating system, then basis (1) throws almost the entire burden of steam cost onto power production. The engines have used nearly 100 per cent of the available power in the steam, and the residual value of the exhaust would be almost zero. This is of course not fair, because if it were not for the heating service which must be rendered in any case, the engines would more than likely be condensing units.

On basis (2), we throw the bulk of the burden onto the heating, since the engines use only about 12 per cent of the available heat, leaving 88 per cent of the original heat in the steam. Ordinarily the heating system would then be debited with 88 per cent of the unit cost of making live steam. The fact is often lost sight of that the heating system cannot possibly use all of the remaining heat and that the returns from a vacuum heating system usually go back to the power plant at about 160-180 deg., depending on weather conditions. This means nearly 140 B.t.u., or more than 11 per cent of the original heat content of the steam, which should not be charged to the heating system. That would leave us 100 — 23, or 77 per cent, which could logically be debited to heating cost on basis (2).

Basis (3) has always appealed to me as being a reasonable method of evaluating exhaust steam, because it permits taking into consideration individual conditions. Assume the case of two friendly non-competing companies, one of which has been established in a given location for a number of years and has a boiler plant of a capacity far more than ample for its own needs. Call it company A. Company B builds a plant adjoining that of A, and the two companies agree that there is no particular point to B having a boiler plant; that inasmuch as A has a heavy power load, giving a considerable excess of exhaust steam over their own heating needs, except over the week-end and on extremely cold days, B might as well purchase its power from the local public utility, and buy its heat from A.

What, then, is a fair price for A to charge B for heating steam? Basis (1) would certainly be unfair to A. Basis (2) might be used, since this basis charges for heat used, and B is buying heat from A. Or, basis (4), which considers the price charged by a company whose business is the sale of heating steam, might be used where such a rate was available.

If the two companies were friendly enough or were controlled by an interlocking directorate, so that it was the policy of both to charge each other on the basis of actual cost, basis (3) might be used and an arbitrary figure established. This would take into consideration the fact that any exhaust steam delivered to B would constitute the sale of an otherwise waste product. It would estimate the amount of live steam which had to be supplied to the heating system—say ⅓. This would be figured at the actual cost of making live steam. The other ⅔ of the heating steam, which would actually be exhaust steam, would be given an arbitrary value which would consider both the sale of a waste product and the fact that B would use, from each pound of this exhaust steam, 77 per cent of the amount of heat contained in a pound of live steam.

Arbitrarily the value ratio for exhaust steam would probably be about one-half, of the cost of making live steam. The price of the heating steam would then be a figure which would combine ⅔ of the quantity at one-half the cost of live steam and ⅓ of the quantity at full live steam cost less credit for the heat returned to A's boiler plant in the hot returns. This seems to me to be a reasonable method of arriving at a price which would be fair to both parties concerned. It would permit A to make an appreciable amount of profit, and would enable B to get heat at a price less than what they could make it for themselves.

Some of the discussions on power plants costs arrive at a unit cost figure for steam and for power by assuming one of these basis for evaluating exhaust steam, and then determining the coal distribution for the entire coal consumption between power-production, heating, and process. Then the resultant coal consumption percentages are applied to all cost figures, such as coal cost, operating charges and fixed charges. The result of this method is that the unit costs of both power and steam are hard to compare, because they both contain the element of uncertainty injected by the use of an arbitrary basis of exhaust steam valuation.

It has always seemed to me to be much more logical and clear-cut to consider first the cost of making live steam up to the point of delivering the steam into the boiler headers. It is usually comparatively easy to determine the cost per ton of laying coal down in the bunkers; this is the main item of steam cost. In a plant of any size at all, boiler room operating costs are usually separate from those of the engine room. These operating costs include labor, supplies, and repairs and maintenance. Fixed charges, such as interest on the investment, rental for space occupied, depreciation on equipment, etc., can also usually be determined or estimated separately for the boiler room.

Division of the cost of supervision between the boiler room and the engine room must be estimated although ordinarily it is about equal. There is still one cost figure left which takes into account the unit cost of power, and that is the cost of current for any motor-driven boiler-room auxiliaries, such as boiler-feed pumps, forced-draft fans and stokers. For these an arbitrary cost per kilowatt-hour, such as 3c, can usually be assumed, and this later modified if conditions warrant adding all these items of cost gives the total cost of producing steam, and if we divide this figure by the weight of water evaporated, we arrive at a unit of live steam cost. This is a figure which is comparable for different plants, and into which there does not enter any arbitrary method of exhaust steam valuation.

Gross unit cost of making current can be calculated in the same manner, and then one of the previously-discussed bases of exhaust steam valuation can be applied to determine how much should be debited to heating and credited to power production. The credit of this amount will then give a net unit cost of power production.

It is believed that a standard method of live-steam cost accounting would be valuable, in that it would permit intelligent comparisons of costs to be made in different industries, and among different plants in the same industries. It would also give a method of arriving at a live steam cost which could be applied to the charges made to different departments in a plant for process steam used—a subject which gives rise to many a heated discussion. It would be interesting also to have some discussion on the various bases of evaluating exhaust steam. Of course, each case is an individual one, with at least some conditions peculiar to itself, but discussion of some of them should bring out points of benefit to all.

Overhauling the Main Turbines at Connors Creek

ALL OF THE TURBINES IN DETROIT EDISON PLANT WHICH IS ABOUT 10 YR. OLD HAVE BEEN ENTIRELY OVERHAULED AND REBUILT

MANY PEOPLE no doubt have wondered how long a modern turbo-generator should last. These modern machines are so smooth running in comparison to the old reciprocating steam engine, that there seems to be prevalent an idea that turbines last forever.

This, however, is not the case, as was shown recently by an article by E. B. Rall, which appeared in the Detroit Edison Synchroscope. This article gave an account of the overhauling of the turbo-generators at the Connors Creek Station of the Detroit-Edison Co.

Connors Creek plant is only 10 yr. old— a mere infant when compared to older electric generating stations. Yet before another year goes by all of the turbo-generators will have been entirely overhauled and rebuilt. This is a comparatively short span of life. It is true that the machines could be operated without rebuilding for a number of years more but this course would necessitate disregarding safety and efficiency which, of course, does not pay.

FIG. 1. NO. 8 TURBO-GENERATOR UNIT AT CONNORS CREEK BEFORE REBUILDING

At Connors Creek there are six units totaling 180,000 kw.; three 20,000 kw., two 45,000 kw. and one 30,000 kw. When in good condition the amount of steam required per hour by these machines is startling but, when the turbine is in need of overhauling, the steam rate is increased by a large amount.

At Connors Creek the result of overhauling shows a material gain in efficiency for the units. Based on an average load, a net saving of approximately 192,000 lb. of steam per day results; and assuming that a unit runs 300 days a year, a net saving of 7,200,000 lb. of coal per year is effected.

When a new turbo-generator is delivered, it is accepted from the builders at a guaranteed steam rate for various loads and is put through a series of tests by the technical engineers of the production department. If it is guaranteed for 10 lb. of steam per kw-hr. at a certain load and after a year or so the steam rate starts to rise, the plant engineering staff begins to hunt for the cause. Steam rate tests are checked against the first tests. The figures will show whether or not the trouble is internal. If it is decided that the trouble is internal, an examination is made of the turbine, the casing is removed by the maintenance department and a check made of wheel clearance, wheel blading, diaphragm ring and shaft sleeve packing and steam nozzles. The generator field and armature coils are also inspected at the same time and if signs of excessive deterioration are found the machine is dismantled and repaired.

FIG. 2. PART OF THE 15TH, 16TH AND 17TH STAGE WHEELS, SHOWING WORN BLADING

In the accompanying illustrations are shown views of a 17-stage turbo-generator in process of being rebuilt at the Connors Creek Station. On July 13, 1925, after an inspection of No. 8 turbo-generator, the maintenance department was instructed to dismantle the machine. Five days later the wheels and field of the generator were on their way to the plant of the manufacturer for rebuilding.

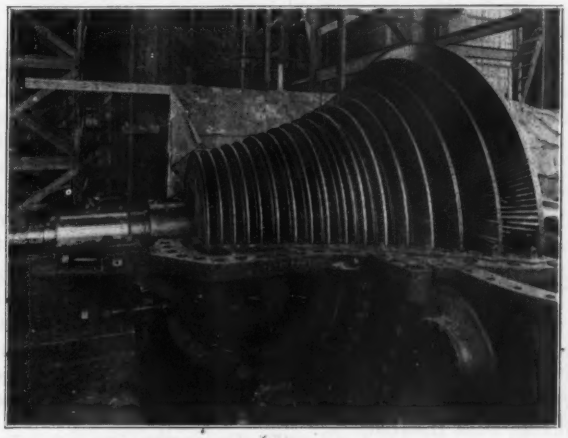


FIG. 3. SEVENTEEN STAGE STEAM ROTOR IN POSITION IN LOWER HALF OF TURBINE CASING

Figure 1 shows No. 8 unit, which is rated at 30,000 kw., completely assembled. In Fig. 2 is shown a closeup of the worn wheel blading and in Fig. 3 a view of the turbine rotor in position in the lower half of the turbine casing. Pictures were not taken of the diaphragm or shaft sleeve packing but they were also badly worn. In the picture on the contents page is shown a closeup view of the ends of the armature coils and in Fig. 4 a view of the field after it has been taken out of the machine casing.

To the uninitiated the defects in the armature coils and in the field would hardly be noticed but, because of worn blading, worn diaphragm ring packing and worn shaft sleeve packing, puffed ends of armature coils and loose blocking on the field ends, the whole unit had to be rebuilt. Advantage was taken of the necessity for making these repairs to rewind the field and armature in such a way that instead of being rated at 90 per cent power factor, as was formerly the case, it will now be rated at 80 per cent power factor.

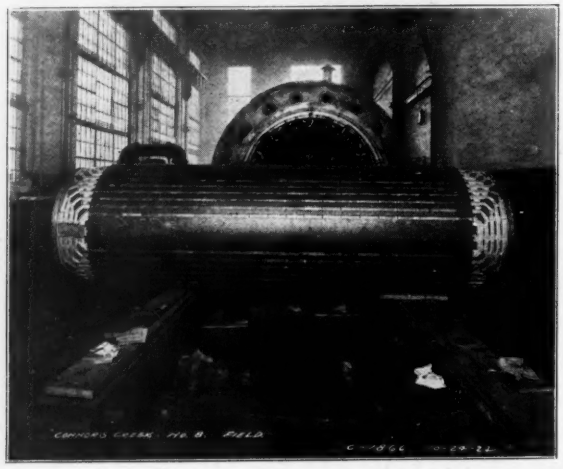


FIG. 4. VIEW OF THE FIELD AFTER BEING REMOVED FROM MACHINE

The Turbine

All the wheels were taken off the shaft. Between each wheel a shaft sleeve packing of a new type was installed and new diaphragm ring packing was installed in the diaphragms. The function of the shaft sleeve packing and diaphragm ring packing is to prevent the flow of steam from one set of wheels to the next set of wheels without first passing through the nozzles. The diaphragm is a solid casting having nozzles or openings near the rim that guide the steam to the blades on the wheel, the steam being directed to the blades in such a way that the wheel is caused to revolve. The clearance between the nozzles and blades is exceedingly small. Blades that were badly in need of repair were straightened and cleaned and, where they were so worn as to make repair impossible, new blades were inserted.

After the wheels were entirely overhauled, they were given a test to determine the vibration characteristics by means of a mechanical vibration device clamped upon the rim of the wheel. In testing for vibration in this manner, the wheel is driven by a motor and by increasing or decreasing the speed, the wheel can be made to vibrate to any desired node and in this way the critical speeds can be determined. For best results the critical speed should not be too near the operating or running speed of the turbine. The safety of a turbine wheel can positively be determined by this method and the safety of a whole set of wheels assured.

After the vibration test, the wheels were assembled on the shaft and the new shaft sleeve packing inserted. A new operating governor, which is not as sensitive as the old one, was installed. Another improvement made was the provision of an emergency governor of the oil ring type. This device automatically cuts off the steam supply to the turbine by tripping the throttle valve in case of overspeeding. A new thrust bearing of the Kingsbury type was installed and the coupling which connects the turbine shaft with the shaft of the generator was also renewed.

The Generator

As was stated previously, the field and armature of the generator were fitted with new coils, not so much because of actual necessity but because by doing so it was possible to change the power factor from 90 to 80 per cent. Surface air coolers were installed under the generator giving the machine the same method of cooling that is used at the new Trenton Channel Station of the Detroit Edison Co. This is the first unit of the Connors Creek plant to be equipped with air coolers.

The entire field of the generator, as well as the turbine rotor, was sent to the manufacturers. The assembly of the blades on the turbine wheels and the winding of the field is a painstaking piece of work and it was not possible to do this work in the power station at Detroit.

STATISTICIANS FIGURE that New York City, with about 6,000,000 people in the five boroughs, is using more electricity than twelve countries of Europe with a combined population of 109,000,000. The Geological Survey calculated that in 1923 the public utility plants of the whole country produced 55,674,435,000 kw-hr. Of this majestic, imponderable total, New York State yielded nearly 9,000,000,000, and Pennsylvania was second with almost 5,500,000,000.

AN INCREASE IN workability and possible reduction in cost are the principal reasons why lime might be used to advantage in cement mortars, according to results secured by the Bureau of Standards, Department of Commerce. When lime plaster is gaged with cement, it still retains considerable of its former workability, and has gained in strength, while the time of set is reduced. A cement mortar with lime added requires extra mixing water, but this extra water increases shrinkage possibilities; therefore, lime should be limited in cement mortars where it is desired to keep shrinkage low. It is possible to keep shrinkage low by the use of a high percentage of sand in any mortar. The density of lean cement mortars may be increased by the addition of a small percentage of lime. Where the cement mortar is not richer than 1:2, the addition of lime may result in increasing the strength.

WHEN EXPANSION BENDS are installed in steam or hot water lines, the bends should be sprung open as far as possible, as often considerable additional expansion length may be added to the bend in this manner.

Reasons for Oil Engine Failures

MISALINEMENT, IMPROPER LUBRICATION, AND FAILURE OF COOLING WATER ARE THE MOST IMPORTANT POINTS. BY C. H. S. TUPHOLME

FROM A CLOSE examination of a large number of oil engine failures it is apparent that such failures are nearly always due to a few specific parts, which are always more liable to cause accidents than others. Chief among these are the crankshaft, connecting rod bolt and cylinder jacket.

Crankshafts are nearly always made of ingot steel, and when a fracture occurs it is usually found that it is not of recent origin, but has gradually been developing for some time, often months, occasionally years. Such a fracture generally occurs at the junction of the crankpin or the shaft with the crank web. What probably happens is this: A surface crack is set up in the first instance and this is gradually developed until there is not enough sound metal to carry the load; it is then that the final fracture occurs.

Much may be learned from an examination of one of these fractured crankshafts. It will usually be noticed that quite a considerable area of the fractured surface is black and oily, and is worn smooth by the relative movement of the two surfaces. Such an appearance sometimes leads engineers to the conclusion that the failure is due to an old defect or to a flaw in the metal. Though such a conclusion is somewhat natural in the circumstances, the fracture is generally due to some overstress, and a test of the shaft material, in a good engine, would show the metal to be sound.

It will also be noticed that the cracks seldom run longitudinally, though a crack in one of the journals often runs diagonally.

As might be expected, that part of the shaft which is most likely to fail is where it is most highly stressed, i. e., between the flywheel and the crank. In the earliest stage the cracks are difficult to see and a slight surface mark is not easily distinguished from a crack.

If a crack is suspected a spring test may be carried out as follows: Place a block of wood under the crank web, and then exert a pull on the flywheel rim so as to put the portion of the shaft which contains the suspected crack in torsion. The surface should be rubbed quite clean, and if there is a crack it will show up after a few pulls at the flywheel, as oil will be exuded from the fractured part.

Anything which causes a shock at the moment of explosion is likely to overstress the shaft, and an engine which has been subject to pre-ignition, or has been worked with a slack flywheel key, is very likely to break down sooner or later with a broken crankshaft. The effect of a slack flywheel key is similar to a suddenly applied load, as instead of the load being smoothly transmitted from the piston to the flywheel rim and then back again to the driving pulley, there is a slight movement of the shaft backwards and forwards in the flywheel boss, resulting in a series of blows. As the effect of applying a load suddenly is to double its intensity, it is evident that a slack flywheel key may result in stressing a shaft far beyond the point for which it was designed.

Another cause of overstress in the shaft is sticking or seizing of the piston. Some manufacturing processes require irregular and sudden applications of the load, which, unless carefully regulated, may cause overstress of the crankshaft in the same way as the sticky piston.

If all the bearings are in line and the shaft correctly bedded, there should be no bending moment on the crankshaft as the stress will be torsional. When, however, fractures occur across the webs, it may be taken that the shaft is subject to bending due to the bearings being out of line and in all probability the outer bearing is no longer in correct alinement with the engine frame. By carefully gaging the distance between the webs with a micrometer gage, both when the crank is at the top and when it is at the bottom, the amount by which the webs are sprung out of true parallel can be measured and the height of the outer bearing adjusted until this springing is eliminated.

Persistent heating of the centre bearing, excessive endwise movement at the ends of the crankshaft, or a slight "wobble" at the rim of the flywheel may result from such bending, and, if observed, should at once be attended to.

In another way, also, hot bearings influence the life of a crankshaft, since, if it is overheated, the journal may develop surface cracks and if the shaft is moderately highly stressed, one of these otherwise harmless cracks may form the starting point for a much more serious crack.

CRANKSHAFT MAINTENANCE SUMMARIZED

As far as the failure of crankshafts is concerned, attention should be concentrated on the following points:

1. See that the piston and combustion chamber surfaces are clean and free from carbon deposit, as such a deposit is likely to become incandescent and to cause pre-ignition.

2. Make sure the flywheel is keyed tight and that no movement, however, slight, can take place between the flywheel boss and the shaft.

3. Keep the surfaces of piston and liner clean and the cylinder lubricator in good order. Use a good engine cylinder oil, it will pay.

4. Attend regularly to the main bearing lubricators. These bearings are usually of the ring-oiled pattern, and the oil wells require occasional cleaning out and filling with fresh oil, otherwise the oil may become too thick and the rings will cease to revolve.

5. Have the alinement of the shaft bearings checked from time to time by a man who knows his job.

The failure of the connecting rod bolt is one of the most frequently recurring accidents, and owing to the extensive damage which often results, repairs are a costly matter and the engine is likely to be out of commission for a considerable time. It has been estimated that the failure of the connecting rod bolt is responsible for 25 per cent of oil engine accidents.

A broken piston and liner and bent connecting rod is the least amount of damage which may be expected and in some cases the engine has been completely wrecked through failure of one of the connecting rod bolts. As the piston is not infrequently shot out of the cylinder, there is also considerable risk of injury to life and property other than the engine itself.

Bolts break through overstress, and in most cases this overstress is caused by faulty adjustment of the brasses, resulting in knocking. Other causes of overstress in the connecting rod bolts are preignition, seizing or sticking of the piston and, in the case of small engines, using excessive force when tightening up.

In a correctly adjusted bearing the two halves of the brass are quite hard up together, while there is just sufficient clearance between the pin and the brass to allow of a film of oil. In no circumstances must a bearing be run with a space between the brasses and the bolts slack. If necessary, a thin liner may be inserted at this joint, but the bolts must be quite tight and the brasses solidly together.

If the brasses are too slack on the pin through wear and there are no liners at the joint which can be removed to let them together, they require "stripping," i. e., removing, careful filing across the joint and bedding. After adjustment to give the proper working clearance on the crown of the brasses, further clearance must be allowed at the sides of the brasses for a distance of 1½ in. to 2 in. on each side of the joint, so as to permit the free flow of oil.

Crankpin bolts are commonly fitted with double nuts, so that when adjusted and tightened up the nuts may be locked together they are also fitted with a split pin for security. As a rule, when first sent out from the makers this split pin is hard up against the outer nut, but after the brasses have been adjusted once or twice there will be a clearance between the split pin and the nut. This clearance should be filled up with one or more washers so as to prevent the nuts from slacking back.

Users of gas and oil engines are advised to renew the connecting rod bolts every three years if an engine has been operating over ordinary industrial hours, say eight hours a day. It is advisable to obtain a new set of bolts from the makers, but if for any reason it is necessary to have bolts made elsewhere the greatest care must be taken to ensure that both the material and the design are suitable.

In most of the better gas engines the shank of the bolt is turned down to a diameter equal to that at the bottom of the thread, and the change from one size to another is not sudden so as to leave a square shoulder but is gradual. This is an important point as a bolt subjected to repeated stress will fail much sooner at a sudden change of section than at any other point.

Poor Circulation Cause of Failures

Overheating, due to defective water circulation, is the commonest cause for the cracking of cylinder castings. In most gas engine installations circulation through the jacket is on the "thermo-syphon" system. With this system circulation is set up and maintained by the rising of the hot water in the pipe and as the force producing circulation is only very slight the pipes and water spaces must be kept clear.

In such a system the force which causes the circulation is the difference in weight between the column of hot water and the column of comparatively cold water in the pipes, and in order to obtain a sufficient force and ensure a fairly brisk circulation the tanks must be placed at a high level relative to the engine. The bottom of the tanks should not be lower than the center line of the engine, and wherever practicable should be a foot or two above it. The return pipe from the engine to the tank should rise gradually throughout its length and should have no dips where air could be trapped nor any sharp bends.

When circulation is taking place correctly it will be found, on feeling the tanks with the hand, that each tank is hotter at the bottom than at the top, while there is a gradual drop in temperature from the bottom of the hot tank to the bottom of the cold tank. Should it be found that a tank is cold at the bottom and warm at the top it may be taken that water is finding its way across the top, and the baffle plate should be attended to at once.

Another point which requires watching is to see that the water in the tanks is at the correct level, that is, high enough to cover the return pipe, but not so high as to overflow the top of the pocket. When a ball tap is fitted the water level will be automatically maintained, but when the tanks are filled by hand the level soon falls by evaporation and leakage and the tanks require constant filling up.

Scale in the pipes or jacket is probably the commonest trouble of all as most water puts down more or less deposit when heated. If the city water supply is known to be hard, it is advisable to avoid its use as far as possible by collecting water from roofs or similar means. Whenever the jacket water spaces are washed out and scale removed the joint of the return water pipe on the top of the jacket should be broken and the pipe itself cleared, as here is a point where deposits are likely to accumulate.

Overheating is not the only danger, as jackets have been cracked through using very cold water and several such accidents have occurred in ice-making plants where cold water from the refrigerators has been passed through the engines.

Whenever cold water from a city main is used it is necessary to regulate the quantity carefully, so as to give an outlet temperature of 120 deg. to 150 deg. F., and it is also important to fit a funnel on the outlet so that the temperature may be checked from time to time, and also that, should the supply be cut off at any time, the fact will be noticed at once.

Water Should Be Guarded Against Freezing

Many gas and oil engines are in use only at irregular intervals, and in such cases it is necessary to guard against the risk of a cracked jacket owing to the water freezing.

It is not only engines located in outbuildings, on farms, sewage pump stations, and the like, which are liable to become frozen up, but the hazard applies, in a greater or less degree, to plants in any situation.

Some users leave a gas jet burning near the engine, or if the ignition is by hot tube they keep the Bunsen burner alight. This, however, is not adequate provision if the frost is severe, and a gas jet, to be effective, must be placed immediately below the jacket, and not several feet away. A safer plan is to drain the jacket, but when that is done it is necessary to make sure that the stop cock is tight. In a number of cases jackets have been frozen up when the stop cock was shut owing to its being leaky. The drain tap is usually of small size and if it is dripping an icicle is soon formed, which seals the tap, with the result that the jacket fills up and, if the frost holds, a burst jacket is the result.

Bursting of the stop tap occurs frequently, and though renewal is not an expensive matter much inconvenience is caused through the engine being out of use till a new one can be obtained. These stop taps are usually made with a hollow plug, and when closed the plug remains full of water, which may freeze up and burst the tap. An accident of this kind may be guarded against by drilling a drain hole in the plug in such a position that when the tap is shut the hollow plug will drain itself.

In most cases the tap is placed in a vertical position, and all that is required is to drill the plug at right angles to the port. In other cases, however, it may be found that the stop tap lies in a horizontal position, and it will be necessary to provide both the shell of the tap, as well as the plug, with a small drain hole. It is not essential that the drain hole be in such a position that the plug will entirely empty itself, although that is desirable when it can

be managed. If the plug is even half emptied of water there is not much risk of its being burst.

It is not an uncommon thing to see a piece broken out from the front edge of the piston. This may have occurred through the connecting rod bolts breaking, but in many cases it has been caused when overhauling, by allowing the connecting rod to fall against the piston when withdrawing the piston and rod.

Before uncoupling the connecting rod at the crankpin a piece of timber should be laid in the engine bed onto which the rod can be lowered, and after the piston and rod have been withdrawn care is necessary to avoid letting the rod fall sharply against the piston mouth when placing them on the floor.

Should there be a tendency for the flywheel key to work loose, this should at once be attended to, as a slack key not only causes overstress in the crankshaft, but is likely to result in a crack developing in the flywheel boss. A loose flywheel is sometimes caused by the bore of the boss being slightly larger than the crankshaft diameter, in which case it is unlikely that a single key will be sufficient, and an additional key should be fitted at right angles to the original one. This second key need not be sunk in the shaft but may be fitted as a saddle key.

If the flywheel is a good fit on the shaft but is slack owing to the key being small, it is only seldom that a satisfactory job can be made by fitting a liner under the key: in such cases a new key should always be fitted.

Proper Oil Bearings Are Necessary

Another accident which occurs with frequency is the stripping of the scroll wheel teeth through which the side shaft and the governor are driven. In a few cases this stripping is caused by the teeth being worn or too deep in gear, but in the greater number it is due to the side shaft or the governor spindle seizing. The more modern engines are fitted with ring-oiled bearings for the side shaft, but in older patterns lubrication of this part is by hand and seizing is directly due to neglect of lubrication.

Ring-oiled bearings are automatic in action as long as the oil well is supplied with clean oil and the rings are revolving freely. In course of time, however, the oil becomes gummy, and unless the well is cleaned out and refilled the rings will commence to stick and the journals will go dry and seize.

Ordinary plain bearings, fitted with a worsted lubricator or an oil box, should be attended to at each starting and stopping time, the worsteds being removed and replaced, or the oil box refilled as required.

Fracture of the valve levers occurs more often when the engine is being pulled round by hand than when it is at work, and is caused by the valves sticking on their seats owing to a tarry or gummy deposit. Before pulling the engine round the valves should be lifted by depressing the levers to see that all is free. Failure of the valves sometimes takes place as the result of sticky valve spindles, the valves failing to close until the explosion occurs, when they are banged on to their seats with excessive force.

Another minor failure which often causes a good deal of trouble is fracture of the small oval flange of the sparking plug or the inlet valve. These breakages are caused in re-making the joint, when the flange is strained and ultimately cracks across. When these fittings are being replaced it is necessary to see that the spigot is entered straight and not canted so that it is liable to bind. The two nuts should then be carefully tightened up, without using undue force, making sure that one nut is not being screwed down hard on the flange while the other remains easy.

While this article does not cover all the potential causes of disaster in oil engines, if some attention is paid to the points mentioned the life of the engine will be prolonged and money will be saved in averting breakdown.

Centrifugal Compressors for Diesel Engines

Decrease in Weight and Cost of This Type of Compressor Adds to the Merits of a Diesel Engine*

DIESEL ENGINES are well established, as far as thermal efficiency is concerned, and most builders are now making efforts to secure a more favorable situation with regard to power output for a given weight and cost. One development in this direction, which is proceeding quite rapidly, is the use of high-speed centrifugal compressors for scavenging and supercharging both two-cycle and four-cycle engines. The use of high rotative speeds has decreased to a remarkable extent the weight and cost of many types of apparatus, and the use of centrifugal compression gives some of this advantage to the Diesel engine.

The centrifugal compressor consists of an impeller carrying properly shaped blades, which rotates at high speed in a casing with suitable inlet and discharge conduits. There is appreciable clearance, so that no rubbing or sliding occurs. Such compressors are now in extensive commercial use both in this country and abroad, for supplying air for various purposes. Types which supply air at pressures of from 1 to 5 lb. per sq. in. are being used commercially with Diesel engines.

Air for 2-stroke cycle engines has been supplied by crank-case compression, by a reciprocating blower, either timed to deliver at the opening of the scavenging port or delivering to a constant-pressure receiver from which air is supplied to the engine or by centrifugal compressor delivering to a receiver. The last method gives more constant pressure.

For 4-stroke cycle engines, supercharging with air under pressure gives an increase in the weight of the charge, hence in the power delivered by the engine, and by increasing the pressure of the scavenging air, the same effect can be secured in 2-stroke cycle engines.

Centrifugal compressors have usually been motor-driven; two marine sets have had 180-hp. d.c. motors at 230 v. and 1150 r.p.m. driving through herringbone gears, compressors of 12,000 cu. ft. min. capacity at 2 lb. sq. in. and 3600 r.p.m. In another plant with four 6-cylinder 2-stroke cycle engines of 3250-hp. each, at 127 r.p.m., the air was supplied by two centrifugal compressors of 34,000 cu. ft. min. capacity each against pressure of 1.75 to 2.1 lb. sq. in. with a third compressor as standby.

On one ship, the Tiradentes, use of supercharging increased the power from 3100-hp. to 3600-hp., using a pressure of 0.85 lb. sq. in. at expenditure of 33 kw. input on the driving motor. Exhaust temperature was increased and exhaust valves had to be reground every 40 days instead of the 60 days required without supercharge.

*Abstract of a paper presented at A.S.M.E. annual meeting, New York, Dec., 1925, by S. A. Moss, research engineer General Electric Co.

In appearance the centrifugal compressor resembles the fan blower but internal design is more like a centrifugal pump, rotative speeds and air speed through the apparatus is much higher. In European practice drive has been by special high-speed, direct-connected motors, but American sets have had lower speed standard motors driving through step-up gearing. British ships, which are required to have steam for pumps and heating, have used steam turbines as drivers. Drive by a.c. induction motors is possible also by gas turbines operating from Diesel engine exhaust.

Curves shown, taken from tests of a G.E. compressor with constant position of the field rheostat on a d.c. motor, indicate slight variation of pressure with variation of air volume drawn, but decrease of speed as the load increases. Pressure variation of some 15 per cent may be obtained by varying the field rheostat resistance. Load is varied by changing inlet opening to the compressor or by the opening of outlets from the piping system into which the compressor discharges.

When serving a Diesel engine, the compressor should have a butterfly or gate valve on the inlet and is started, before the engine is started, with this valve closed and run at the lowest speed possible. As the engine is started and attains speed, the compressor inlet valve is gradually opened until the pressure desired is produced, speed being controlled by the field rheostat.

Compressors for furnishing starting air may be fed by the scavenging or supercharging compressor, increasing the high-pressure compressor capacity some 15 per cent. Also air for the centrifugal compressors may take air from places which need ventilating, thus serving a double purpose.

Advantages of the centrifugal compressor are small weight, space and cost, better low-speed operation of the engine, low power cost and ease of providing oversize and duplicate compressors. Also maintenance, labor and cost are low. While size needed is not yet definitely settled, builders are providing 3.5 to 4 cu. ft. actual air per engine brake horsepower.

Supercharging with pressures from 0.75 to 30 lb. sq. in. has shown gain in net power and saving in fuel but increase in pressure at the end of expansion. This gain is due to greater weight of charge in the clearance volume, better cleaning of the cylinder and clearance, decrease of percentage of heat carried away by the cooling water, greater power with given cylinder and crank friction—these being slightly offset by some decrease in the area of the indicator diagram.

Increase of 6 to 30 per cent in charge is secured by supercharging at 1 to 5 lb. sq. in., the increase being greatest for large clearance percentages. Better cleaning of clearance space, especially around the fuel-injection nozzle, and setting up of air current permit better combustion and the burning of an increased percentage of fuel with less excess air. Higher pressure at the end of expansion results in some loss of area at the toe of the diagram, but this is not great. As water jacket loss is less proportionately, if an engine is barely able to keep cool at its maximum power, supercharging should not be tried. But a number of engines are now operating successfully and it is probable that any types which give trouble with supercharging can be altered to give satisfactory operation.

Admission of scavenging air, at little more than atmospheric pressure, after the exhaust port of a 2-stroke cycle engine is closed, can hardly be classed as supercharging; but, if engine parts and cooling system can be arranged to stand the increased power the 2-stroke cycle engine can have the same gain as the 4-stroke cycle by supplying scavenging air at higher pressures or by a second compressor to supply the supercharging air with mechanical valve opened at the proper time.

The author also explains possible methods of driving compressors by exhaust gas, one having been used to some extent on airplane engines but not yet tried out extensively for stationary practice.

Operators of steam turbines are often troubled with oil throwing or oil leakage at the bearings of the machine. This trouble can generally be traced to one or more of the following causes:

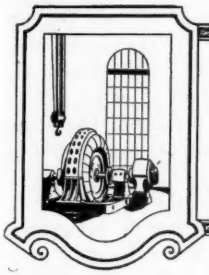
1. Excessive oil pressure in the oil circulating system which causes more oil to be delivered to the bearings than can be properly taken away by the overflows or return pipes. The remedy for this condition is the lowering of the pressure. This pressure, however, should in no case be lowered below ten or twelve pounds gage.

2. Leaky joints between the bearing caps and housings or between halves of the oil deflectors. The horizontal joints between caps and housings should be carefully cleaned and made up with shellac whenever the joints are broken. The oil deflectors should be tight in the rabbets provided for them and the grooved deflector should be located in the lower half. If the clearance with the shaft has become too great the oil deflectors should be replaced.

3. Excessive pressure in the housings. The screens in the oil separators should be removed and cleaned and if necessary additional vents should be installed in the housings. A piece of pipe about 15 in. long, with a goose neck on its outer end, makes a good housing vent.

4. The oil fans may be located too far away from the ends of the housing to be effective. These oil fans should be located as near as possible to the stationary oil deflectors without limiting the end travel of the rotor as determined by the thrust bearing.

In the operation of oil-burning boilers, every precaution should be taken to prevent the collection of unburned gases in the firebox, boiler passes and economizers. A supply of prepared torches should be kept handy at all times. These torches should consist of iron rods of sufficient length to reach the burner tips, made with asbestos rope wound and wired to the ends of the rods in such a manner that it is securely fastened thereto. The torches should be kept standing in a container of coal oil, ready for use. When a boiler is lighted up from standing cold, at least two of these torches should be lighted and inserted into the firebox in close proximity to the burner tips, before the fuel oil is turned into the furnace. The torches should be left in the firebox until the oil is burned off them, to insure the fires being thoroughly lighted. If the fires of a newly lighted boiler become extinguished, the fuel oil valves should be promptly closed and the dampers of the boilers opened in order to allow the combustible gases to pass up the flue. In no case should another lighed torch be inserted into the firebox for at least five minutes after the dampers have been opened.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Motor Drives for Centrifugal Fans and Blowers

SELECTION OF MOTORS FOR DRIVING CENTRIFUGAL FANS REQUIRES A CLOSE STUDY OF FAN CHARACTERISTICS. BY GORDON FOX

IN DISCUSSING the application of electric motors to driving centrifugal fans and blowers it is essential to consider carefully the various characteristics of these devices. In much the same manner that a generator may be under or over compounded, giving either decreased or increased voltage with variation of load, fans may be designed to give either decreased or increased pressure as the delivery increases. The curve showing the relations between pressure and delivery is commonly termed the fan characteristic. The performance characteristics of a fan are controlled largely by the shape of the impeller blades. A fan of the radial blade type develops its maximum pressure at "shutoff" and the pressure developed falls off as the discharge resistance is decreased and the volume increased. The characteristics of a fan of this type are shown in Fig. 1. A multi-blade fan having forward directed blades has a considerably flatter characteristic, the pressure being better maintained at higher capacities.

In some designs the pressure rises from the point of shutoff pressure at zero discharge to a considerably higher pressure at rated delivery. This characteristic is shown in Fig. 2. A high speed fan having backward curved and inclined blades gives a pressure which may rise slightly above the shutoff pressure for small volumes but which drops rapidly over the normal working range. The characteristics of such a fan are shown in Fig. 3.

The power required to drive any centrifugal or propeller type fan or blower is a function of the volume and the pressure or vacuum obtained. For a given fan and restriction of discharge, (1) the horsepower varies directly with the density of the gas or air handled and is therefore also affected by the temperature. (2) The pressure

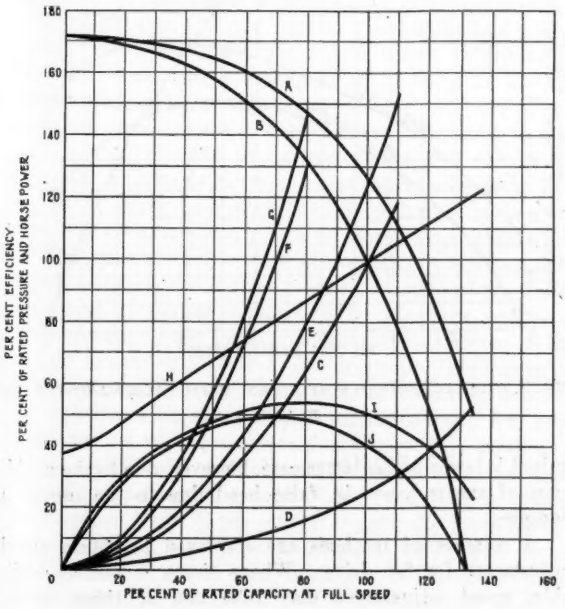


FIG. 1. CHARACTERISTICS OF A FAN OPERATING AT FULL SPEED WITH RATED DISCHARGE AND THROTTLED TO GIVE 80 PER CENT OF RATED DISCHARGE

A—Per cent of rated total pressure developed. B—Per cent of rated static pressure developed. C—Static pressure required by system. D—Velocity head. E—Total pressure required. F—Static pressure required by system when throttled to give 80 per cent of rated discharge. G—Total pressure required by system when throttled to give 80 per cent of rated discharge. H—Per cent of rated horsepower required. I—Per cent total efficiency. J—Per cent static efficiency.

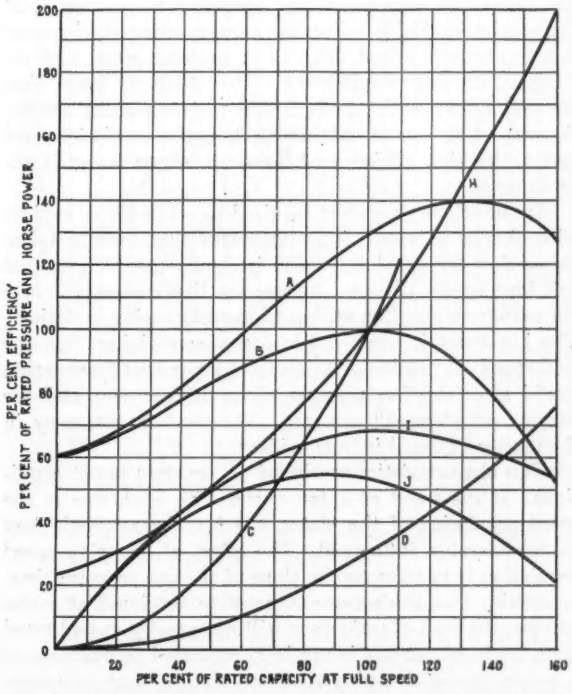


FIG. 2. CHARACTERISTICS OF A MULTI-BLADE FAN HAVING A RISING PRESSURE CHARACTERISTIC

A—Per cent of rated total pressure developed. B—Per cent of rated static pressure developed. C—Static pressure required by system. D—Velocity head. E—Total pressure required. H—Per cent of rated horsepower required. I—Per cent total efficiency. J—Per cent static efficiency.

varies as the square of the speed. (3) The torque varies likewise as the square of the speed. (4) The power varies approximately as the product of pressure and volume or torque and speed and is therefore proportional to the cube of the speed.

$$HP = \frac{5.2\ Q \times P}{33{,}000 \times e} = \frac{0.0001575\ QP}{e}, \text{ in which}$$

5.2=lb. pressure per sq. ft. 1 in. water gage

Q=volume, cu. ft. per min.

P=total water gage pressure

1.728 × pressure in ounces per sq. in.

e=total fan efficiency, approximately, 50 per cent for paddle wheel fans, 60 per cent for multi-vane fans, 60 per cent for high speed fans, 25 per cent for propeller fans.

Motor Selection

Most centrifugal fans operate normally at constant speed and with more or less constant load. For such drives shunt wound direct current motors or squirrel cage induction motors are commonly used according to the nature of the service available. For the larger units synchronous motors are well suited, both as to constant speed and infrequent starting requirement. The speeds of many fans are well suited to direct connection to synchronous motors. Because of the usual continuous operation and high load factor, the high efficiency of the synchronous motor is advantageous.

Inasmuch as the power required by a fan varies rapidly with change of speed, it is important that care be taken to see that the rated fan speed is closely met. The actual full load speeds of shunt motors are likely to vary 3 to 5 per cent from rated speed, due to manufacturing variations. The hot speed is usually 3 to 5 per cent higher than the cold speed. A resulting variation of 6 per cent from rating would alter the fan pressure about 12 per cent and the motor load about 19 per cent. The need for accuracy in the matter of speed is thus evident.

Fan characteristics are based on constant speed conditions. If the speed of a fan varies with load, due to the speed regulation of the motor, the fan characteristic may be considerably influenced. The effect of drooping speed regulation is to increase the slope of the fan pressure characteristic. Due to decrease of pressure developed at excess volume, the load of some fans will not greatly exceed rated load. This characteristic can be accentuated through use of a motor having drooping speed regulation, such as a compound wound motor or a wound rotor induction motor with a small amount of fixed secondary resistance in circuit.

In case the system voltage is subject to considerable fluctuation the use of the compound wound motor is to be advised for fan drives. Fan drives ordinarily have considerable inertia, leading to high current peaks in a motor subject to fluctuating voltage.

Speed Control

The delivery of a centrifugal fan, blower or compressor may be reduced by throttling the inlet or discharge by a damper. This increases the system pressure and causes the fan to operate at a higher pressure and lower volume point on its characteristic. This condition is indicated in Fig. 1, wherein curve C is the normal system characteristic with damper open. The fan, operating at the intersection of curve B, representing static pressure developed and curve C, representing static pressure required, delivers 100 per cent capacity at 100 per cent pressure. If the system pressure required is increased to curve F by partly closing the damper, the fan will deliver 80 per cent of rated volume and will develop 130 per cent normal pressure. The power required under normal conditions is 100 per cent and at 80 per cent volume 87 per cent of rated power is required.

Figure 4 gives the characteristics of the same fan operated at 80 per cent of rated speed to deliver 80 per cent of rated capacity. System curves C and E are the same as in Fig. 1 and no damper is used. It is to be noted that 80 per cent volume is here obtained with 64 per cent of rated pressure and 51 per cent of rated horsepower. In the first case the fan operates at about 48 per cent static efficiency and in the latter case it operates at 40 per cent static efficiency. The overall efficiency is higher and the power required is lower in the latter case, however, due to the avoidance of excess losses in false head due to the use of a damper.

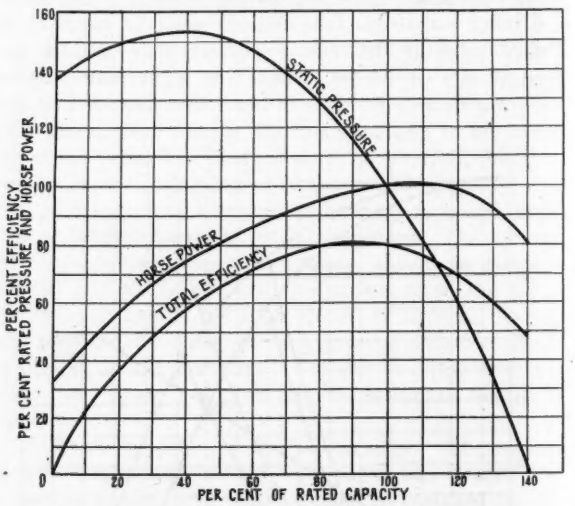


FIG. 3. CHARACTERISTICS OF A FAN WITH BACKWARD CURVED BLADES

A number of methods are employed to obtain speed adjustment for fan drives. Where direct current is available, speed adjustment may take one of three forms, namely:

Regulation by armature resistance.

Field control.

Combination control.

Armature control is obtainable at the lowest first cost because the normal speed of the motor then corresponds to maximum speed of the fan and a smaller motor frame may be used to deliver the required horsepower than when the motor is rated at a lower speed. The cost of the control equipment required for this method of regulation is somewhat higher than when field control is used but this does not offset the difference in motor cost.

Armature control is relatively inefficient in operation. The losses in series resistors are not proportional to the speed reduction but increase more slowly to a maximum of about 15 per cent of motor rating at 60 to 70 per cent speed. As the power required to drive a fan varies as the cube of the speed, halving the speed reduces the power requirement to ⅛ of that corresponding to full speed. Hence the wastage of power at reduced speeds with series

resistance control is less serious, for a fan drive, than for a load having a constant torque characteristic.

Field control generally involves higher first cost for the reason that an adjustable speed motor is essentially a constant horsepower unit. Therefore, the rated horsepower of the motor must be that corresponding to full speed of the fan while the rated speed of the motor corresponds to minimum fan speed. However, since the greatest load does not occur at low speed and since modern adjustable speed motors will carry slight overloads safely at increased speeds, it is permissible to motor closely or to use a motor having a higher rating at high speed than at low speed. Such tapered ratings are given by some motor manufacturers.

Selection of the proper type of direct current equipment depends upon the range of speeds desired, the extent of operation, the prevailing operating speeds and the cost of power. For small motors, narrow speed ranges and cheap power conditions, the lower first cost of an armature control installation will generally justify its selection. Where the motor operates for long intervals at speeds between 50 per cent and 100 per cent maximum speed, field control will show sufficient economy to justify its greater first cost. If the motor operates long intervals at speeds between 75 and 100 per cent and occasionally at lower speeds, combination control is best suited. Combination control is commonly arranged to afford 10 to 25 per cent speed reduction by armature control.

Where speed control is desirable and alternating current only is available, the wound rotor induction motor with secondary resistance control is most commonly used. This method of driving parallels the direct current motor with armature resistance control. Due to the usual steady load of a fan, this method of control ordinarily supplies a sufficiently constant speed at any setting in spite of the drooping speed regulation characteristic. As fans ordinarily operate continuously for long periods the inefficiency of this method of driving may be a consideration. This method of drive is ordinarily considerably more efficient than constant speed drive with damper regulation. Except for some shortcomings in the matter of efficiency this method of drive is ordinarily entirely satisfactory where the speed control range does not exceed 50 per cent. Due to conversion losses of 20 to 25 per cent, it is generally more efficient to drive with a wound-rotor induction motor with secondary resistance control than to convert to direct current in order to use field control.

In some cases the resistor losses are of sufficient magnitude to warrant the installation of a brush-shifting type of polyphase series motor. This motor has a speed characteristic very similar to that of the wound-rotor induction motor but, at considerably reduced speeds, the efficiency is higher, due to elimination of resistance losses. This type of motor is relatively expensive. Whether or not its higher first cost is justifiable must be determined for each case through a study of comparative economies under prevailing conditions. The brush-shifting type of motor is available in sizes up to 175 hp. at 1200 r.p.m. and 350 hp. at 600 r.p.m.

In some instances speed control has been obtained with alternating current drives through the use of two wound-rotor induction motors direct coupled to the opposite ends of one fan. The larger motor is rated for the full speed of the fan and is large enough to carry the full fan load at this speed. The smaller motor is wound for some lower synchronous speed and has sufficient capacity to drive the fan at that speed. Only one motor is used at a time. Secondary resistance control of the larger motor is used to provide intermediate speeds. Secondary resistance control of the smaller motor is used to provide the lower speeds. The economy of this combination as compared with the use of a single large wound-rotor induction motor or a brush-shifting motor is illustrated in Fig. 5.

In case of very large fans such as used for mine ventilation, speed adjustment may be desirable primarily due to extension of the mine workings. In many cases the fan speed is occasionally changed by adjustment of pulley sizes. If a motor of adjustable speed type is desired the use of Kramer or Scherbius sets is frequently warranted due to the large powers involved and the continuity of operation, which render the matter of power cost important. The constant torque type of set is applicable but the actual fan

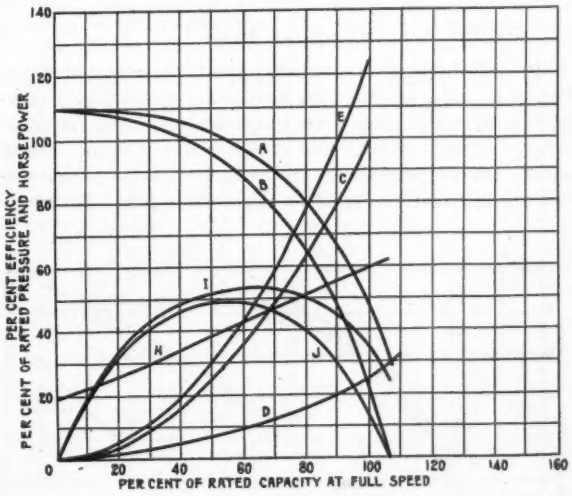


FIG. 4. CHARACTERISTICS OF FAN SHOWN IN FIG. 1, DRIVEN AT 80 PER CENT RATED SPEED TO REDUCE DISCHARGE TO 80 PER CENT NORMAL

A—Per cent of rated total pressure developed. B—Per cent of rated static pressure developed. C—Static pressure required by system. D—Velocity head. E—Total pressure required. H—Per cent of rated horsepower required. I—Per cent total efficiency. J—Per cent static efficiency.

load characteristics should be considered in determining the capacity of the auxiliary equipment.

Starting Considerations

Ordinarily the starting torque required by a fan or blower is low. In the case of large, slow speed fans the static friction may be rather high. In most cases there is considerable inertia load involved in accelerating the fan. Starting resistors for use with controllers for large fans may require extra heat dissipating ability due to slow acceleration necessitated by high inertia load. The air delivery load is practically nil at starting and builds up as the fan and motor attain speed. If a centrifugal fan starts with discharge closed, the maximum air load taken in churning at shut off pressure is ordinarily about 25 per cent of rated load. It is advantageous to start any large fan under shut off conditions to minimize the accelerating current demand but this practice is particularly desirable when synchronous motors are used. Synchronous motors have been employed to start fans under load conditions with damper open, but they are likely to be larger and more expensive than when more favorable starting conditions may be afforded. A self-starting synchronous motor for driving a fan should have a low resistance cage wind-

ing capable of dissipating considerable heat. The low cage resistance is allowable because of the low static torque and is desirable to enable the motor to approach closely to synchronous speed by induction motor action and thus minimize the pull-in requirement which is rendered more severe because of the inertia of the drive.

Automatic control is frequently supplied for fan drives. This may be arranged to respond to pressure or vacuum gages for starting and stopping and diaphragm regulators for speed control. Under-voltage release may often be desirable as contrasted with under-voltage protection to afford automatic starting and insure maximum continuity of service. Line switch control is sometimes used, in which case the motor starts automatically when the feeder switch is closed and runs so long as the power remains on the line.

Propeller Fans

Propeller type fans commonly operate at constant speed. For small units single phase motors are applicable. Squirrel cage induction motors are commonly employed for alternating current drives. For direct current, shunt wound motors are commonly used on the larger units. Series motors are frequently applied on the smaller fans. They pro-

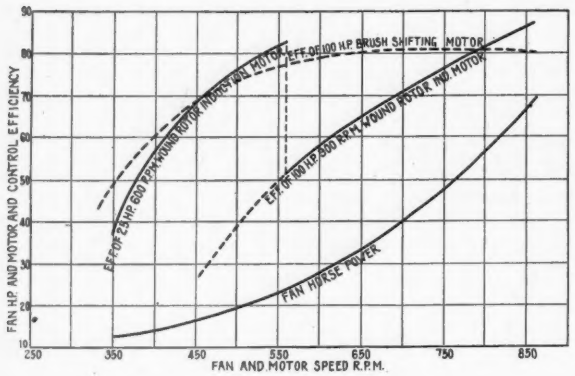


FIG. 6. COMPARISON OF METHODS OF SPEED CONTROL OF FANS USING A-C MOTORS

tect themselves automatically against severe overload by slowing down under load increase. Small series motors driving fans can be started by connecting directly across the line. The series motors develop high starting torque per ampere input and the starting load is small. The power required by a propeller fan may be determined by the same formula as that given for centrifugal fans. A formula based on fan dimensions and speed is given below:

$$HP = C(D^5N^3 \div 10^{10})$$

Where C = a constant varying according to design, usual values being 0.15 to 0.50

D = diam. of fan in ft.

N = revolutions per minute.

Because the passage of air tends to draw dirt into the motor, it is not uncommon practice to enclose small motors driving propeller type fans. The air movement is helpful in cooling the motor. The use of ball bearings is advantageous both because of the inaccessible location of many of these equipments and also because of the tendency for the air suction to draw oil of the bearing next to the fan when an oil lubricated bearing is used.

Large Synchronous Condenser Installed on West Coast

WHAT IS SAID to be the largest condenser of the synchronous type ever built was recently put in service on the 220,000-v. transmission system of the Mount Shasta Power Co. of California, partially supplying San Francisco and the surrounding Bay country with electric energy. The condenser, placed in operation for voltage regulation in the high potential transmission system, has a rating of 40,000 kv.a. at 0 per cent leading power factor and 25,000 kv.a. at 0 per cent lagging power factor. It is used, however, with a lagging power factor characteristic only during periods of starting or light load, during which time the line voltage might rise to an abnormally dangerous point. Under ordinary load conditions a leading current in the condenser is desired to correct for normal voltage drop in the system.

This condenser was built by the Westinghouse Electric and Manufacturing Co. and was placed in operation in the same substation with two other synchronous condensers of a similar design but having ratings of 20,000 kv.a. each at 0 per cent leading power factor. The new machine will operate at 11,000 v., and has a synchronous running speed of 600 r.p.m.

It is installed at the Vaca Dixon substation of the Mount Shasta Power Co., a subsidiary of the Pacific Gas and Electric Co., approximately 200 mi. south of its first generating unit located at Pit River. The substation is the first in the transmission system running from Pit River to the San Francisco district and power is converted from 220,000 v. to lower potential for immediate transmission to distribution centers of consumption.

Totally enclosed this new condenser is constructed with a chimney-type frame having double enclosing sheet-steel end-bells. The stator winding is of the standard form-wound, open-slot type. Because of its great size, however, and resulting difficulties of transportation, it was necessary to wind the stator in two sections.

On account of the high peripheral speed of the rotor—over 15,000 ft. per min. at synchronous speed, special consideration was essential in the design of the rotor and the damper windings. In view of this, the rotor was constructed out of built-up rolled-steel plates and punchings, which assured that only materials of known and tested uniformity entered into that portion of the machine where the greatest strains exist.

A new construction was used in securing the damper windings of the rotor to the short-circuiting rings. The individual bars in each pole piece were welded at either end to a separate copper segment, having a length equal to the width of the pole, which in turn was joined to the continuous short-circuiting end-rings by bolts.

Condensers must justify their use by actual savings. Great importance has therefore been placed on low losses as well as correct characteristic, for power factor correction and voltage regulation. The machine delivered to the Mount Shasta Company operates at full load with total losses of only about 2 per cent of its kv.a. rating.

By the use of oil pressure at about 800 lb. per sq. in., during starting, it is possible to start the condenser on 5000-kv.a. and bring it to speed in less than 5 min. By increasing the starting voltage and using a correspondingly higher starting kv.a., the time required to bring the condenser up to speed can be materially lessened.

High Speed Motors and Frequency Changers*

HIGH SPEED INDUCTION MOTORS IN FACTORIES ARE USUALLY SUPPLIED BY SPECIAL GENERATORS OR FREQUENCY CHANGERS. BY CHARLES FAIR

MOTOR SPEEDS HIGHER than those obtainable from the ordinary commercial frequencies (25 to 60 cycles) are now being extensively used in connection with such machines as shapers, molders, tenoners, carving, grinding, and drilling machines, etc. Inasmuch as the utmost in both mechanical and electrical refinement is now required of the direct-motor-driven machine, it is highly desirable to know how to obtain commercially the required higher motor speeds.

Since the squirrel-cage alternating-current motor is the ideal motor for high-speed-motor applications, and since three-phase current has been universally adopted, in order to avoid confusion this type of motor only will be considered.

The speed of a polyphase squirrel-cage type of induction motor is definitely fixed by its number of poles and the supply frequency. For a 2-pole motor, the synchronous speed (full-load speed, slightly less) will be 60 times the frequency; for a 4-pole, 30 times; a 6-pole, 20 times, and an 8-pole, 15 times.

If no a.c. source of supply is available, an a.c. generator may be built to give any frequency and voltage desired; but if a commercial circuit furnishes current, a frequency-changer is used to give the higher frequency needed. Such a machine is essentially a wound rotor type, slip-ring induction motor, driven backwards by belt or motor drive. Current supply is usually connected to the stator and high-frequency output taken from the slip rings of the rotor.

FREQUENCY CHANGERS FOR BOOSTING FREQUENCIES

The frequency changers considered here are those used for boosting frequencies, and may for convenience be divided into two general groups.

One group boosts frequency and voltage together for using standard motors to be run at higher speeds. This method seldom goes above 120 cycles, as standard motors are limited in the speed at which they can run, by insulation, rotor stresses, bearing friction and tendency to draw oil from the bearing reservoir. For a 2-pole, 220-v. motor, running 3600 r.p.m. on 60 cycles, the speed would be 4800 r.p.m. on an 80-cycle, 293-v. circuit, or 7200 r.p.m. on a 120-cycle, 440-v. circuit, but it would hardly be safe to go to this last set of conditions because of insulation and mechanical stresses involved.

In a second group, special frequency-changers are used to boost from any standard frequency and voltage, 2- or 3-phase—first to a new standard of 120 cycles at 225 volts; second to a new standard of 200 cycles at 114 volts. Specially designed and wound motors are used for these new standard conditions. The first series will operate over a range from 80 cycles at 150 v. to 199 cycles at 373 v., giving speeds for 2-pole motors from 4800 to 11,940 r.p.m. The second series will operate from 200 cycles at 114 v. up to 500 cycles at 285 v., giving 2-pole motor speeds of 12,000 to 30,000 r.p.m. High-speed limits for motors depend on mechanical considerations and low-speed on ventilation requirements. Large frequency-changers and those boosting at high frequency ratios, at 25 to 200, must have a large number of poles to avoid excessive speed.

The speed of the frequency changer at a given secondary frequency is fixed by the primary or excitation frequency and the number of poles of the frequency changer. The kilowatt rating is usually given at a definite secondary frequency and voltage, and will vary from this rating practically in proportion to the variation in the secondary frequency. The output of the two-pole motors in sizes generally used on the higher-frequency circuits will increase or decrease somewhat less than at a straight frequency ratio, depending upon how far the frequency varies from that at which the motors were rated.

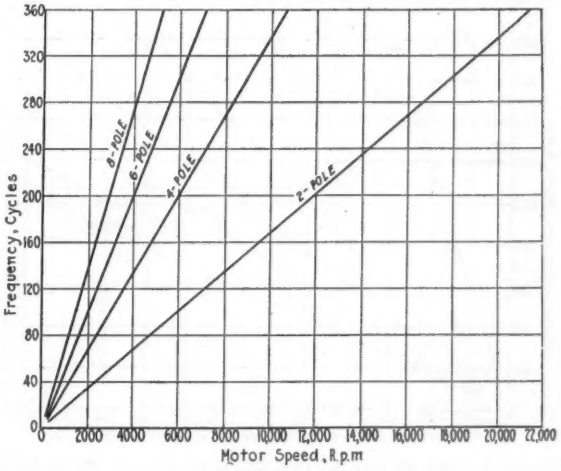


FIG. 1. INDUCTION-MOTOR SPEED CURVES FOR VARIOUS POLE AND FREQUENCY COMBINATIONS

DRIVE FOR FREQUENCY CHANGERS

Frequency changers can be driven from any source of power available, but the excitation must be alternating current, three-phase or two-phase. By rotating the machine in the opposite direction from that which it would normally run as a motor, the frequency generated by rotation is automatically added to the frequency of the excitation circuit. If the rotor be driven backward at normal speed, that is, the speed at which it would run as a motor on the primary frequency, then the normal line frequency will be obtained as through a transformer, plus an equal number of cycles due to rotation.

To increase or decrease the secondary frequency of a given machine it is only necessary to increase or decrease the speed of the frequency changer. The secondary frequency is equal to the frequency of excitation, which remains constant, plus the variable or generated frequency, which is a function of the speed of the rotor.

As stated, the frequency changer is driven backward from what it would run as a motor and the frequency that it delivers will be that of the supply circuit plus that generated by the rotation. Delivered frequency can, therefore, be varied at will by varying the speed at which the

*Abstract of a paper delivered before the Annual meeting of the A. S. M. E., New York, N. Y., Nov. 30 to Dec. 4, 1925.

rotor is driven and the required speed of the rotor will be:

$$\text{R.p.m.} = 120(S - P) \div N$$

Where S and P are secondary and primary cycles per second and N is the number of poles.

Frequency changers are usually rated in kilowatts, 0.8 power factor, and at a definite secondary frequency; but due to the fact that they can be run at such a wide range of speeds, approximately three to one, the actual kilowatts will be greater or less than the rated kilowatts, depending upon the speed at which the frequency changer is driven. If the kilowatt rating is given at 120 cycles and the machine is run at a speed to give 180 cycles secondary, then the kilowatt output would be increased 50 per cent. Likewise, if the same machine were run to deliver 90 cycles, the output would be reduced 25 per cent.

Power Required to Drive Frequency Changers

There has always been a great deal of confusion over the question of the power required to drive frequency changers at various speeds, due, no doubt, to an imperfect understanding of the workings of the machine. To facilitate this the following formulas which take into account efficiency have been developed.

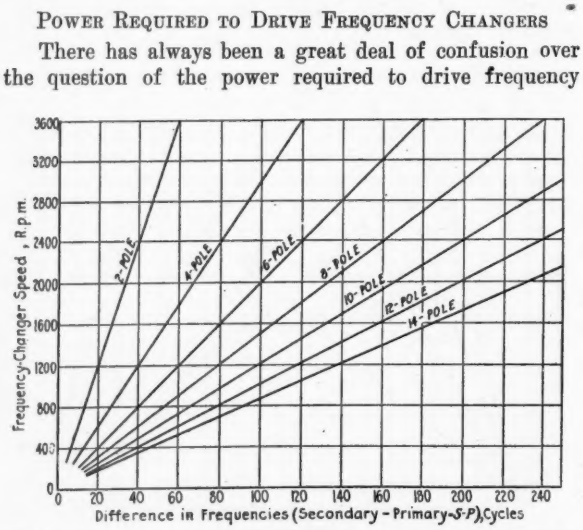


FIG. 2. CURVES TO DETERMINE SPEED AT WHICH FREQUENCY CHANGER MUST RUN FOR VARIOUS POLE AND FREQUENCY COMBINATIONS

Power required for driving will be:

$$\text{Hp.} = 1.49R(S - P) \div F$$

where S and P are as before and R is the kilowatt rating at the given frequency, F.

Excitation

The excitation of a frequency changer at full load is to the total energy as the primary frequency is to the secondary frequency. Similarly the mechanical energy to rotate the machine is to the total energy as the difference of frequencies is to the secondary frequency.

$$\frac{\text{Electrical}}{\text{Total}} = \frac{P}{S} \qquad \frac{\text{Mechanical}}{\text{Total}} = \frac{S - P}{S}$$

When boosting from one of the lower standard frequencies, 25-60 cycles, to a higher frequency, the secondary should be three-phase and the voltage should correspond to one of the established standards, as 110 v. or 220 v. at 60 cycles with corresponding frequency and voltage up to 199 cycles, or the high-voltage limitation when starting with 220 v. at 60 cycles. The second series begins with 200 cycles, 110 v., and runs up to 500 cycles, 275 v. and beyond. Standard motors can then be used and interchangeability maintained to a large extent.

An exception to the foregoing might be the case of boosting from 25, 30, or 40 cycles to only 60 cycles as a standard; and when it is not intended to boost the frequency any higher, and where transmission is a factor, then 60 cycles at 440 v. would be considered.

Motors can be wound for 2/4 pole combinations to run at speed or half-speed on the higher frequencies as well as on standard frequencies. When the voltage is in the proper ratio to the frequency the same motor can be run on two or more frequencies as, for instance, on a 110-v., 60-cycle, or 220-v., 120-cycle circuit.

The output of two-pole motors will increase or decrease from normal rating approximately in proportion to the increase or decrease in speed up to 120 cycles and beyond, heating the limiting factor at slow speeds. Four-pole motors, 110 and 220 v. at 60 cycles, up to approximately 15 hp. can generally be speeded up to a 100 or 120 cycles, with an increase in output nearly in proportion to the speed. Larger motors and motors of more than four poles should be given individual consideration before running at higher than the rated frequency.

Electrical companies generally do not advise speeding up motors of standard bearing construction. It is understood that the bearings of high-speed-motor applications are a part of the machine design.

The number of motors that can be successfully operated from a given frequency changer depends upon the size of the motors, their duty cycle, and the power factor. Because the frequency changer is a separate power unit, it must be of sufficient capacity to start the largest motor; otherwise the requirements are estimated as for standard frequencies, with due regard to power factor.

The use of frequency changers for boosting standard frequencies is no longer either new or novel.

Improvements in the electric motor have been responsible for marked changes in the design of machine tools.

Woodworking-machinery manufacturers alone are using thousands of high-speed and built-in motors. The percentage of motor-driven to belt-driven machines has materially increased in the last few years, one company having developed the direct-motor-driven machine to the point where its production of this type has increased in the past six years from 30 per cent to 90 per cent of their output, making the belt-driven machine seem almost obsolete.

Sale of the Maine & New Brunswick Electric Power Co. and the Aroostook Valley Railroad Co., known as the Arthur R. Gould properties, to the Albert E. Pierce Co. of Chicago, is confirmed at the headquarters of the companies at Presque Isle, Me. The first payment on the deal, involving more than $3,000,000, is understood to have been made. The Gould Electric Co., a subsidiary, is included in the purchase. The Gould company serves a population of over 50,000 in Aroostook county and a large number of important industries. The railroad is a line 38 mi. long operated by electric locomotives and permission has been given the road to build a 30-mi. extension from its terminus at New Sweden, Me., to St. Agatha. The total assets of the railroad are given as $1,400,000 and of the power companies as in excess of $1,000,000.

The steam connections to boiler feed water regulators should be made at the highest possible point in the boiler steam space to insure dry steam.

Pneumatic Sweeping Systems in Power Plants

Broom Sweeping Is Inadequate and the Dust Explosion Hazard Makes Suction Systems Desirable. By F. C. Allen, Jr.*

WHY SHOULD POWER PLANTS be kept clean? In general, for the same reason that any other type of building inhabited by human beings should be kept clean.

In addition to the desirability of cleanliness in promoting the health and welfare of the human element, there are other specific reasons why the dust in power plants should be frequently removed and disposed of. For example, there is the fire and explosion hazard in coal dust as well exemplified in the serious explosions that quite frequently occur in coal mines as well as in power plants. This dust explosion hazard is no doubt especially great in plants where coal is pulverized as the finer the particles of coal the more explosive the dust becomes. Many have the impression that the dust explosion hazard involves only the dust which is floating in the air or, in other words, "suspended" dust. On the contrary, the dust which presents the greater hazard is the dust frequently referred to as "static" dust, i. e., that which has settled and accumulated on rafters, side walls, boiler tops and other interior surfaces.

This may be briefly explained by the fact that there are always two different stages of dust explosions, i. e., the primary and secondary explosions. The primary is the initial flash of dust in the air. This in itself is seldom serious being local in character and no great pressure being generated in view of the comparatively small quantity of dust involved. If, however, the interior of the building is covered by an accumulation of static dust, there is sufficient force of concussion from the initial flash of the suspended dust to jar loose the piles of dust on rafters and overhead surfaces. This dust therefore comes falling down just in time to meet the flame of the initial flash with the result that the secondary explosion is a much heavier detonation, a much larger quantity of dust being involved. Still another reason for power plant cleanliness is the well recognized psychological influence of clean surroundings. Men are not as efficient when working in dirty, uncomfortable places as when the surroundings are pleasant and agreeable.

Pneumatic Suction Systems Are Supplanting Brooms

Much interesting progress has been made during the past few years in power plant cleaning. Gradually the old-fashioned push broom seems to be used less and less as the ineffectiveness of this tool becomes more apparent. Floors are not really clean when swept with brooms and a large percentage of the dust is merely swished into the air to settle again in some other place. Again, brooms and brushes are especially ineffective when it comes to the removal of dust from overhead rafters, boiler tops and similar places where dust soon collects in large quantities so that apparently, the best and most efficient way to remove such dust accumulations is by means of a powerful suction system.

Many power plant engineers have had the idea of using vacuum cleaners for this work. In many instances such machines have been tried but it is obvious that the ordinary type of vacuum cleaner, designed for hotel or residence service, is entirely inadequate for power plant service where the quantity of dust is so much greater and where the hours of service are so much longer. During the past three or four years a number of the larger power plants have been equipped with pneumatic sweeping systems. These systems function in precisely the same way as the ordinary vacuum cleaner, the chief difference being that these pneumatic sweeping systems are more powerful and have much greater dust storage capacity. Industrial equipment, to answer fully the requirements, must be considerably more rugged in construction and properly designed for hard continuous service.

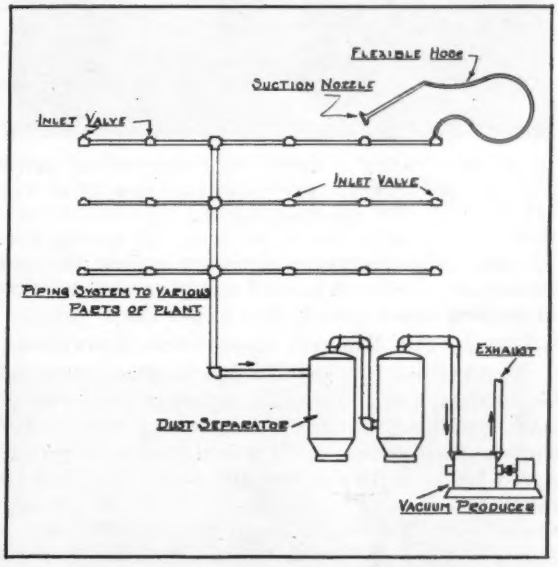


FIG. 1. OUTLINE OF PRINCIPLE PARTS OF SUCTION SWEEPING SYSTEM FOR POWER PLANTS

Pneumatic sweeping systems have four distinct elements, as follows:

1. Portable nozzles, handles and suction brushes
2. Conduit lines consisting of flexible hose and (in stationary or installed systems) rigid pipe lines
3. Dust separating tanks
4. Vacuum producer

These four elements are clearly shown and indicated in Fig. 1. In some instances, heavy duty portable equipment best answers the requirements, as, for example, in a case where the work to be done does not justify the cost of complete piping installation. Stationary equipment is generally to be preferred and represents the most ideal condition for with this equipment there is nothing to move about the building except the hose and nozzles and no time is lost in moving the machine from place to place as in the case of portable equipment. Another frequently serious objection to portable equipment is that the dust separating tank must necessarily be small in size and therefore has limited storage capacity for dust and dirt. In plants where there is a large quantity of material to be removed and collected, as for example in a power plant or a grain elevator, it is obvious that portable equipment would be entirely inadequate, owing to the comparatively limited capacity of

*President, Allen & Billmyre Co.

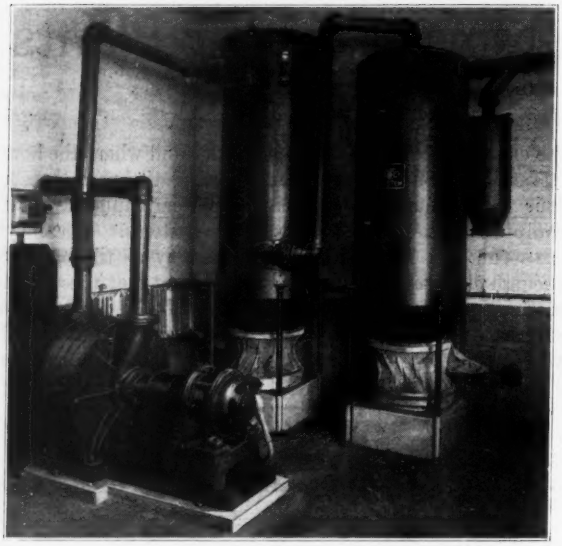


FIG. 2. THIS PLANT IS KEPT CLEAN BY A MOTOR DRIVEN CENTRIFUGAL SUCTION FAN DRAWING THE DUST INTO SETTLING TANKS

the dust tanks, whereas in stationary systems the tanks can be made of sufficient size and storage capacity to answer all requirements.

INSTALLATION REQUIRES ENGINEERING KNOWLEDGE

That the designing and installing of these systems calls for knowledge based on practical experience just the same as other specialized branches of engineering work, is quite obvious. Each element of the system must be properly designed for the particular work to be done; therefore each installation is more or less of a separate problem to be worked out. The failure of any one element means the failure of the entire system to function properly. During the past three or four years much progress of an important nature has been made in the designing and installing of these industrial sweeping systems. The installation of these systems is becoming more and more frequent in various kinds of industrial plants and more particularly in plants where dusty conditions prevail as in the case of power plants, rubber factories, grain elevators, flour mills, baking powder factories and similar lines of industry.

It is interesting to note that a highly specialized type of exhauster or vacuum producer has been developed for this class of service. This exhauster seems to answer all requirements, both as to theoretical performance and practical operation. The type of exhauster referred to is the horizontal, multi-stage centrifugal type, as shown to the left in Fig. 2. This machine maintains a high vacuum while exhausting a large volume of air. Having but one working part and no wearing parts, this exhauster is not injured by the small percentage of dust which escapes through the dust separators. Furthermore, it is self-governing in its action and automatically maintains a uniform vacuum.

For different installations it is necessary to install dust separating tanks of varying size and capacity; but the general type of separators used is also shown in Fig. 2. It is customary to install 2 tanks connected in series. The air and dust first enters the primary separator which separates and retains all of the heavier particles of dust together with about 90 per cent of the finer dust. The air then passes through into the secondary separator which is arranged with suitable means for filtering the air and arresting practically 100 per cent of the remaining dust. In power plants these separators are frequently installed in the top of the building over the coal bunkers to enable the separators to be discharged directly into the bunkers. In this manner, the collected material, consisting largely of coal dust, requires no further handling and is automatically burned. In industrial plants the more common practice is to install the machine and separators in the basement or on the first floor of the building; but the systems are equally effective whether the dust is drawn upward or downward. A number of the larger power plants have recently installed mammoth sweeping systems of the type referred to. These systems are not only proving effective for the removal of dust from floors, walls, boiler tops and other interior surfaces but also for the effective removal of the troublesome siftings which accumulate around the stokers.

The piping systems, by means of which the vacuum service is distributed in various parts of the building, must obviously be properly designed and laid out to suit the requirements of each installation. It is imperative that long sweep, smooth bore fittings be used to prevent cloggage of material in the pipes and it is important that the pipes be of ample size to accommodate the flow of air without excessive frictional loss.

Half Truths Are Half Lies

BY WILLIAM SIBLEY

One of the curses of the present time is the unthinking acceptance of half truths by many people. Because of the unreadable amount of reading matter that is foisted every day and every month on the long-suffering public, we have become wont to skim the surface of things and to pass snap judgment.

Since the Great War, the Constitution of the United States has come in for a great deal of attention and discussion. Many people, perhaps sincere but certainly sadly deluded, advocate abolishing that bulwark of our republic, either in toto or by amending it beyond recognition, thus accomplishing the same result.

As examples of the statements in some discussions of the Constitution and the Declaration of Independence, they are quoted as saying that "all men are created equal," and it is argued that we have lost track of this provision because, in this country, all men are not now equal.

At no time did our forefathers who framed the constitution ever entertain the idea that all men are created equal or that ours would ever be a nation where such a condition would exist. What the Constitution did say was "all men are created equal before the law," which is quite a different statement from the quotation as usually given.

There are those who fairly delight in pointing out our lack of "liberty," blaming that lack on the Constitution. The men who, after great strife and effort, brought forth the Constitution, held the word "liberty" in far greater respect that we of today. They used the word wisely, not promiscuously. When they said "liberty" they did not mean "license" and they did not promise even liberty. They promised the "blessings of liberty," which, we submit, is quite a different thing.

All those who utter half truths with respect to our government and the provisions of our constitution, are, in effect, uttering half lies and should be classed accordingly.

Welds Made Stronger Than the Welded Material

TESTS ON ORDINARY WELDS SHOW HOW THEY FAIL AND METHOD BY WHICH WELDS WERE MADE THAT TESTED STRONGER THAN THE BODY OF THE MATERIAL. BY H. A. WOODWORTH

BEFORE installing some 3000 ft. of 20-in. pipe which was to stand a test of 500 lb. and work at a pressure of 250 lb., it was desired to know what kind of joint would best serve. It was a question whether to pay a large royalty for a special joint or to depend on a butt-welded joint with reinforcing straps. Many letters were written to experts and others were interviewed as to the strength and efficiency of welds in general but the answers seemed to be based more on guess than on tests, so it became necessary to make up some welds and test them to get real facts.

For the first test, we selected a piece of 20-in. steel pipe, cut it in two and then welded it in the ordinary way; after welding, four strips of the same metal were used to reinforce the weld, these strips being straddled across the joint and tacked on at the ends with an electric arc process so as not to burn the welded pipe. The method is indicated in 2a, Plate II. The strips were made 3 in. wide and 8 in. long for the test.

These strips were added, not for extra strength, but to prevent the pipe line failing due to shock or weaving, the strips acting simply as stiffeners.

As it was necessary to have an official test made by a disinterested party, Professor J. L. Vanorman of the department of Civil Engineering of Washington University, St. Louis, was secured to conduct the testing. All joints were made in ½-in. steel cut from the wall of 20-in. pipe, the material having a specification of tensile strength, 50,000 lb.; yield point, 30,000 lb. and elongation 22 per cent in 8 in.

ORDINARY WELDS

First tests were made on Nos. 1, 2 and 3 of Plate I and compared with No. 7, which was a piece of the original pipe material. The illustration is a microphotograph 1½ times the size of the breaks, showing the structure in the breaks.

Figure 1 is an oxy-acetylene weld of a butt joint using a Norway rod. It gave a maximum strength of 39,900 lb. per sq. in., breaking in the weld and showing 75 per cent of the strength of the plate, but it is evident that the weld did not extend all the way through the plate, probably due to not spacing the pieces far enough apart when making the weld. This is an error quite commonly made by welders.

Number 2 was welded with Norway rod and was rein-

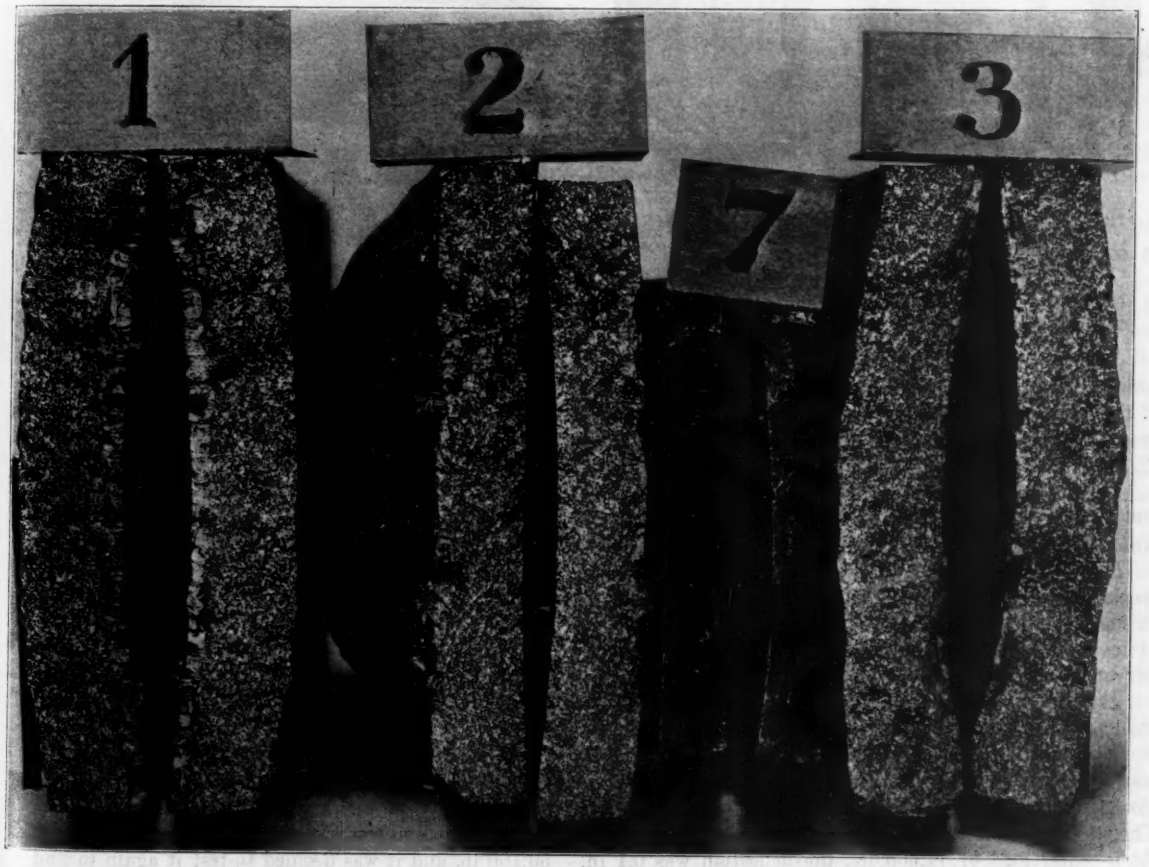


PLATE I. FIG. 1. BUTT WELD FRACTURE, NOT WELDED CLEAR THROUGH. FIG. 2. BUTT WELD REINFORCED, BREAK OUTSIDE THE WELD. FIG. 7. TEST OF ORIGINAL PLATE FROM 20-IN. PIPE. FIG. 3. BUTT WELD CLEAR THROUGH, NO REINFORCING. IN THIS CASE THE STRENGTH WAS 43,300 LB. PER SQ. IN., AN EFFICIENCY OF 81.3 PER CENT.

forced by strips on the outside of the joint. The test showed a strength of 56,000 lb. per sq. in., the break coming outside the weld.

For No. 3 weld, no building up was used and the break came in the weld, the fracture showing that it was welded clear through. The strength was 43,300 lb. per sq. in., an efficiency of 81.3 per cent.

Specimen No. 7 from the body of the pipe broke at 53,300 lb. per sq. in., showing that its strength was above the specification.

Reinforced Joints

As test No. 2 showed that the strap-reinforced joint was stronger than the pipe, it was decided to run another test on this piece. The first test bent the specimen and we found that the second test had a tendency to twist the weld more than ever which caused fracture in the less ductile material, naturally the weld. Due to the bending

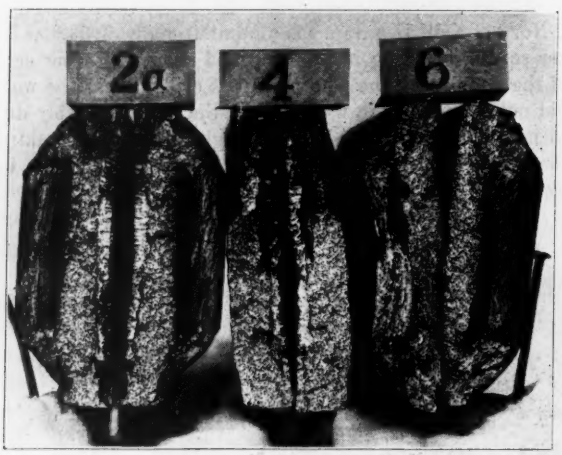


PLATE II. FIG. 2A. SECOND TEST OF JOINT WITH REINFORCING STRIPS, THE JOINT INJURED BY BENDING OF THE PREVIOUS TEST. FIG. 4. BUTT WELD WITHOUT REINFORCING OR BUILDING UP. FIG. 6. RESULT OF BENDING TEST OF REINFORCED JOINT

action, the weld was torn wide open. This strain was out of the ordinary and the test was made to find how much twisting and rough treatment the weld would stand. Plate II, Fig. 2a, shows the break of this joint having reinforcing strips as already described, the strength being only 30,500 lb. per sq. in. due to the strain of the joint during test No. 2 of Plate I.

Figure 4 was a weld of ordinary type made with no special effort or instruction of the welder. It showed a strength of 40,700 lb., or 76.3 per cent of that of the plate and was not welded clear through. It was an ordinary butt weld, made with Norway rod, not built up.

As we could find no data for bending tests on welded steel pipe and felt that the real test of a weld is largely in the bending and twisting of the pipe lines in action as well as from vibration, we deemed a bending and deflection test advisable. The break from this test is shown in Fig. 6, the span being 10 in. and the mandrel 2 in. diam. At a center load of 14,600 lb., the deflection was 0.1 in. at the center; the second reading at a load of 18,000 lb. showed deflection of 0.5 in., while at 60 deg. bend the maximum of 19,700 lb. was obtained. This test piece was an electric weld of a butt joint with reinforcing strip 2 in. by ½ in. and tested somewhat better than oxy-acetylene weld tests for bending which were made later.

Built Up Welds

Considering that the foregoing tests were not sufficiently conclusive, we decided to profit by experience and have welds made as we thought that they ought to be made. The tests as shown on Plate III prove that we have "arrived."

For the joint shown in 3, Plate III, an acetylene weld was made reinforced inside as well as outside the pipe, using Norway iron. The plate broke before the weld showing that the joint was 100 per cent efficient.

PLATE III. FIG. 3. ACETYLENE WELD WITH NORWAY IRON, REINFORCED INSIDE AND OUTSIDE. FIG. 4. PLAIN BUTT WELD WITH 10 PER CENT OUTSIDE REINFORCING. FIG. 5. BUTT WELD WITH NICKEL STEEL. FIG. 6. NICKEL STEEL WELD TESTED TWICE; BOTH BREAKS OUTSIDE THE WELD. FIG. 8. WELD WITH RAILROAD WELDING IRON. FIG. 9. ELECTRIC ARC WELD REINFORCED INSIDE

At 4 is a joint made as a plain butt weld with no reinforcing inside but built up 10 per cent on the outside, Norway welding rod being used. This proved stronger than the plate, the maximum strength being 48,900 lb. per sq. in.

Number 5 was a butt weld, made with nickel steel and reinforced. The test strength was 49,900 lb.—greater than that of the pipe.

On the first test, No. 6, a nickel steel weld broke at 53,100 lb. and it was decided to test it again to find what injury might have been done to the weld in the first test. The second break was at 49,600 lb., both breaks being outside the weld.

For Fig. 8, the weld was made with railroad iron and reinforced, the maximum load being 50,500 lb. per sq. in. with the break in the plate outside the weld.

All the above were acetylene welds and it was decided to test an electric arc weld for comparison. This was made with 10 per cent reinforcing inside the pipe, the break, shown at 9 being at 50,900 lb. per sq. in.

Results of these tests were used to determine the construction of several large underground steam heating installations where it was desired to use high-pressure mains but the owners were uncertain as to the efficiency and dependability of butt welds and to what extent they should be reinforced by metal strips, especially in the larger sizes such as 20-in. Based on these tests, such installations were made in three large cities during the past year and future installations are planned both in the U. S. and Canada.

To the writer, who has used welded joints for the past 15 yr., these tests prove that welding has come to stay. It has long passed the experimental stage and it is immaterial whether it be done by oxy-acetylene or electricity so long as a perfect weld is made and sufficient reinforcing used.

Many Factors Influence Ice Plant Design

Discussion of Fundamental Principles, Showing Their Application by Solution of Typical Problem in Ice Plant Design. By H. J. Macintire

ICE PLANT DESIGN and operation are not the same in all parts of the country or even in two parts of the same town. There are factors which vary widely and which alter the necessary details of the ice plant construction. For instance, because of its bulkiness, ice is usually used where it is made and this usually means (except possibly in the case of car icing) that the ice plant is located in a town or city. If the plant is to be in a city the objections to the possibilities of labor troubles, the inevitable smoke and dirt occasioned by the use of a steam plant and the usual cheapness of electrical power frequently mean the choice of an electric drive and a raw water plant, although the oil engine has great advantages and many are being used. Of course distilled water plants are still being operated extensively but these are usually old plants or in locations where the water is so bad that good can ice cannot be made even when employing the usual softeners and filters. The plate ice system has certain advantages but the disadvantages far exceed the advantages and, in consequence, new plate plants are not being erected. The result is that ice plants are now almost entirely of the low, the medium or the high air pressure agitation types, for raw water can ice, with filters and softening devices in many cases.

The present tendency, also, is towards the reduction of the cost of labor to the minimum possible. This means the use in the larger plants of the 400-lb. cans instead of the 300-lb. cans, as the time of freezing is the same for both and, with the exception of certain patented tank designs, the use of medium or high pressure air agitation. In fact, it has been pointed out that some raw waters heavy in certain salts cannot make the best ice with low pressure air agitation. Low pressure air agitation means the removal of the air pipe just before the pipe is frozen in the cake of ice and, on account of the lack of agitation for the last period of the freezing process, there is always a large white core formed in the cake. With high pressure agitation, de-humidified air is delivered to the can through a tube soldered in the can or otherwise integral with it and agitation is continued until the cake is almost completely frozen; the resulting ice is clear, although there is a little white feather formed at the center of the cake. Besides this, the can does not require attention during the time of freezing, except for the matter of securing continuous agitation but, because the air pipe is in metal contact with the brine in the tank, the air must be de-humidified and the agitation must be absolutely continuous after the lowering of the can into the brine.

The medium pressure air agitation system, in which the air tubes are allowed to freeze into the cakes, does not require a de-humidifier, the pressure of the air need be only 5 to 10 lb. per sq. in. and the air tube can be readily removed by means of a steam thawing needle in a minute or two. The hole left in the ice by the removal of the tube is hardly noticeable and the time of operation required for the removal is comparatively short.

Also the tendency of the times is for heavier agitation than formerly and for the lifting of gangs of ice cans at a time, sometimes from 5 to 18 but in many cases not more than 6. The advantage of lifting more than two cans at a time depends on local conditions and the entire subject is one for careful analysis if the most economical arrangement is to be made. The heavy agitation is for the purpose of increasing the coefficient of heat transfer of the pipes in the tank for flooded operation from 20 B.t.u. per sq.ft. per degree difference per hour (the value k) to 25 or possibly to 30 B.t.u. The particular gain here is to permit the amount of piping in the tank to be reduced, and also to reduce the time of freezing of the water in the cans, although the empirical formula for the time of freezing has no term to denote the effect of agitation on the freezing time. The latest practice is to raise the evaporating or suction pressure as high as possible, say 22 to 25 lb. gage. This means a high boiling temperature of the ammonia and, consequently, greater capacity for the compressor and less cost in horsepower per ton refrigeration but the auxiliary horsepower is increased.

Calculation of Typical Design Problem

Calculating ice plant problems may, then, be different in certain details but the manner of the calculation can be shown clearly by the following problem, the details of which would need to be carefully decided by an analysis of the costs and by a consideration of the power and labor items. The ice plant is to be a 100-T. raw water can ice plant, for 24 lb. suction and 154.5 lb. condenser pressure, using 70-deg. F. water to the cans and 17-deg. brine. The outside air temperature is 90 deg., and the temperature of the earch is 50 deg. F. Use high pressure air agitation, 30 lb., at the compressor and 15 lb. at the cans. Two de-humidifiers, brine cooled, to cool 200 cu. ft. of free air per minute from 90 to 20 deg. F.

Two tanks* of ¼-in. steel will be used, 5 ft. 1 in. high, each to hold 600 cans, 58 in. high and of 400 lb. capacity each. Each tank will have one accumulator and two 12 in. brine agitators, using 5 hp. each, with motors direct connected to vertical shafts. Can centers are to be 2 ft. ⅜

* These details follow the standard practice of a prominent manufacturer.

in. by 14¼ in. and the tanks are to be insulated with 12 in. of granulated cork on the sides and with 5 in. of cork board on the bottom. Lift 5 cans at a time and use 1¼ in. full weight pipe.

1st. To find the heat removed per lb. of ice placed in daily storage

To cool the water from 70 to 32 deg. F.
per 1 lb. of ice..... 38.0 B.t.u.
To freeze the water per 1 lb. of ice..... 144.0 B.t.u.
To cool the ice from 32 to 14 deg. (spec. heat of ice = 0.5)..... 8.0 B.t.u.

Total 190.0 B.t.u.
Add 10 per cent for non-computable losses.. 19.0
Heat leakage through the insulation
= 4475 B.t.u. per hr. per tank or ..... $\frac{4475 \times 24}{2000 \times 50}$ = 1.07 B.t.u.

Sides, 12 in. granulated cork, 2⅞ in. t-and-g cypress.

$$U = \frac{1}{\frac{1}{1.4} + \frac{2}{1} + \frac{12}{0.296}} = 0.0231$$

Bottom, 5 in. corkboard, 9 in. concrete.

$$U = \frac{1}{\frac{5}{0.308} + \frac{9}{5.3}} = 0.0558$$

Heat leakage:
Sides = 1187 × 0.0231 × (90—14)=2090 B.t.u.
Bottom = 3420 × 0.0558 × (50—14)=6860 B.t.u.
Total=8950 B.t.u.

Air for agitation is cooled after compression first by water and then by brine (using two tanks with a four-way valve for alternate change of direction of flow.) The brine, in refrigerating the air, adds a certain amount to the load on the compressor, as for example the heat removed from each pound of the air may be considered as 35.0 B.t.u., and the specific volume of the air as 14.2 cu. ft. Then—

$$\frac{200}{14.2} \times 35.0 = 493 \text{ B.t.u per min.}$$

or, in terms of the ice made,

$$\frac{493 \times 60 \times 24}{100 \times 2000} = 3.56 \text{ B.t.u. per lb.}$$

Agitation of the brine, as already stated, assists in the heat transfer, and keeps the brine temperature constant. Agitation always tends to warm up the brine, and it is customary to figure that the entire heat equivalent of the pump horsepower is converted into heat and has to be neutralized (refrigerated) by the action of the compressor. In this case the amount becomes

$$\frac{20 \times 42.4 \times 60 \times 24}{100 \times 2000} = 6.1 \text{ B.t.u. per lb. ice}$$

The total refrigeration per pound of ice made is then

209+1.07+3.56+6.1=219.7 B.t.u.

In round numbers, the value 220/144 = 1.53 is the ratio of the number of tons of refrigeration capacity required per ton of ice made, according to the calculation. The value usually used is 1.6 although some engineers go to the extreme by the use of the ratio 2.0, but such a large value would only be necessary when careless operation prevails, such as leaky valves and piston rings, when the gas returns greatly superheated to the compressor and when carelessness in maintaining the suction pressure results in reduced capacity.

2nd. To find the tank size, amount of piping, etc., allowing 2 ft. 1⅛ in. by 14½ in. per can, and selecting a tank size 20 cans wide by 30 cans long, a tank 24 ft. 10 in. by 69 ft. 0 in. will be sufficient to provide space for the cans, the agitators and the accumulators, and the tank will be 61 in. deep. The ice can is 11½ in. by 22½ in. inside dimensions at the top and tapers to 10½ in. by 21½ in. at the bottom and is 57 in. long. It is made of No. 14 gage iron, galvanized.

It has been customary to use an empirical formula for the time of freezing which gives an approximate answer. This formula is:

$$t = \frac{7 \times w^2}{32 - t_b}$$ where w = thickness of the ice in inches

t_b = the temperature of the brine. t = the time of freezing in hours. Then

$$t = \frac{7 \times 11 \times 11}{32 - 17} = 56.5 \text{ hr.}$$

As a matter of fact, the time of freezing depends on a number of factors which cannot be stated in the formula. The water entering the cans may be at any temperature from 40 to 80 deg. F. The water may be free of solids, and again the core may be like brine which freezes at a much lower temperature than 32 deg.

Finding Amount of Pipe Required

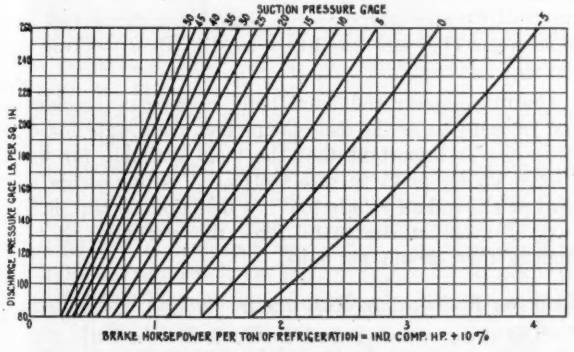
The amount of piping required depends somewhat on the design. With good agitation and the flooded system, a value of 25 for *k* may be expected or the area in square feet of pipe surface per tank = $\frac{220 \times 50 \times 2000}{24 \times 20 \times (17-10.2)} = 6740$

Using the value 2.3 as equal to the linear feet of 1¼-in. pipe per sq. ft. of surface, the total length of pipe per tank becomes 6740×2.3=15,500 ft. Referring to the chart, it will be seen that there is a certain definite relation between the number of cans per ton of ice, the brine temperature and (for a particular value of the coefficient of heat transfer of the piping in the tank) the amount of direct expansion piping. The large number of cans used in the problem permits a high brine temperature but increases the tank size, and, in consequence, the amount of insulation, the frame work and the ground area. The piping in the problem works out as a high ratio and the first cost will be high per ton of ice making. As a rule it is wise to consider (1) the mechanical efficiency of the equipment, (2) the initial investment and (3) the cost of plant operation. Medium sized plants have produced ice at the rate of 37 to 38 kw-hr. per ton of ice as the yearly average, with a load factor of 60 to 70 per cent, but the cost of power is only one of a number of costs. With good agitation and with the flooded system, which makes it possible to decrease the amount of gas in the evaporating system and, by having a heavy feed, to have some liquid in the coils for the entire length of the direct expansion piping, a value of 25 can be obtained for *k*. A design of this sort, however, requires more care in operation than does the more ordinary plant.

Selecting the compressor and the compressor drive has become a difficult problem in these days, with the many types and designs which prevail. A few points of particular

prominence are worth mentioning here. It is a mistake to consider that clearance in an ammonia cylinder means an appreciable loss of economy. Clearance affects the capacity of a compressor but it has not been proved that it increases the horsepower per ton of refrigeration to any great extent, except for the friction of the machine, which remains nearly constant but is relatively larger at small than at full loads per ton of refrigeration.

Space allotted to the compressor frequently determines the type of compressor. The principle of the design makes one feel that the vertical single acting compressor using the suction valve in the piston is the correct design, in order to reduce to a minimum the superheating of the suction gas by the cylinder walls but this is also true of the horizontal design. In each case there is a uniflow principle of gas flow. The factor 0.86 for the volumetric efficiency below is a term to allow for this, although the figure mentioned may be a little low for the vertical, single-acting compressor. One is led to believe, however, that the semi-enclosed type of vertical compressor is becoming much less popular than, say, 10 yr. ago. It has a reciprocating rod type of stuffing-box which is much more difficult to keep



BRAKE HORSEPOWER PER TON OF REFRIGERATION FOR VARIOUS DISCHARGE AND SUCTION PRESSURES

tight than the rotary type used in the enclosed compressors and is likely to have more friction in the stuffing-box. In Great Britain the semi-enclosed type is not used at all, and it is stated that the horizontal compressor has not been built for 5 yr., whereas the 3 and 4-cylinder enclosed machine using forced lubrication throughout is exceedingly popular. In the United States, every manufacturer has a design of a small compressor of the vertical single acting type, but the majority have only horizontal compressors in the larger sizes. One large manufacturing company has developed an enclosed compressor of large capacities, using three cylinders, and having capacities to 300 to 400 t. of refrigeration.

For electric driven compressors requiring 75 hp. and over, the direct-connected synchronous motor usually should be used. The gain is in a greater over-all efficiency, as there are no belt or other transmission losses, which usually amount to 6 or 8 per cent. This type of motor is particularly good because of its ability to improve the power factor of the circuit, since the motor may be made to operate as a synchronous condenser. Its disadvantage, which is true also of the squirrel cage induction and other types of motors, is its inability to vary the speed of the compressor. Variation of the capacity can then be obtained only by the judicious use of clearance pockets, a device which has become quite common. If a steam engine is used, the uniflow engine is the most popular because of the flat water rate curve and the low steam consumption per horsepower-hour. If the oil engine is decided upon, there are a number of types to choose from.

Finding Horsepower per Ton of Refrigeration

In any case, the power delivered to the shaft (see accompanying diagram) for 24 lb. suction and 154.5 lb. condenser pressures, should be 1.10 hp. per ton of refrigeration. Capacity and the horsepower per ton refrigeration can be calculated as follows, for 24.0 lb. gage suction and 154.5 lb. gage condenser pressures:

H (24 lb. g.) $\times$ (86 deg. F.) $= 614.9 - 138.9 = 476.0$ B.t.u.=net refrigeration per lb. liquid ammonia. Theoretical volume boiled off per ton of refrigeration per minute

$$= \frac{200}{476.0} \times 7.28 = 3.06 \text{ cu. ft.,}$$

and with a volumetric efficiency of 0.86 the piston displacement per ton per minute becomes $3.06 \div 0.86 = 3.56$ cu. ft., not allowing for clearance.

The horsepower per ton of refrigeration is obtained from

$$W = \frac{n}{n-1} P_1 V_1 \left(1 - \left[\frac{P_2}{P_1} \right]^{\frac{n-1}{n}} \right)$$

$$= \frac{1.28}{0.28} \times 144 \times 38.7 \times 3.56 \left(1 - \left[\frac{169.2}{38.7} \right]^{\frac{0.28}{1.28}} \right)$$

$$= 34{,}500 \text{ ft. lb.} = 1.05 \text{ hp.}$$

Each of the two compressors will have a capacity of $76.6 \times 1.1 = 84.3$ hp. at the shaft. The piston displacement may be found from the same set of curves and for the conditions stated this becomes 3.6-cu. ft. per ton of refrigerating per minute. Therefore a 76.6-t. machine will require $76.6 \times 3.6 = 276$ cu. ft. per minute for each of the compressors. The type of compressor chosen will affect the rotative speed, but the present practice is to use some form of light weight valve of the plate or the ribbon type. The heavy poppet valve is practically obsolete. Should a synchronous motor be used, clearance pockets may be used to advantage in regulating the capacity of the compressor.

Ice making plants have use for two suction pressures, the second being on the fore-cooler at, say, 35 lb. gage. This is especially true where the water for the cans is 70 deg. F. or higher and where suitable care is taken to prevent much loss due to the warming of this water between the fore-cooler and the cans. If the operating conditions were constant the multiple effect compressor could be used to advantage here, but the conditions are not constant for any length of time. The result is that either a separate machine is used for pre-cooling the water for the cans, or the attempt is made—as it was in the design above—to increase the suction pressure as high as possible.

In choosing the details of the air agitation and the harvesting process, the costs should be carefully considered, as well as local conditions. The high pressure air system was selected for this problem, and also multiple can lifting and filling devices. These decisions should be made with great care. For handling the ice in the larger plants, where labor is expensive and where electrical power is used it is convenient to make use of three motors; one for the hoist, another for the carriage and the third for the bridge.

These should be of the variable speed type and, for use in plants lifting from 5 to 10 cans, the horsepower is 3½, 1½ and 2½ respectively. For agitating brine, a rough rule calls for one agitator for 400 cans or less. If the tanks are 24 cans wide and 20 cans long, two agitators should be used, both at the same end; for tanks over 20 and up to 35 cans long and under 24 cans in width, an agitator at each end would be preferred. Tanks over 35 cans in length and more than 24 cans in width should have two agitators at each end. Although there are notable exceptions, yet an inch or two difference in level of the brine in the different parts of the tank due to the agitation is good practice. If more than this amount is used not only is considerable power consumed, which heats the brine, but the difference in the brine level must be allowed for in the location of the cans in the tank.

The de-humidifier is necessary in every case where the air is made to pass into the can through a pipe in metal contact with the brine, because with 16 to 18 deg. F. brine some moisture in the air is precipitated and frozen unless the water content is reduced previous to bringing the air to the can. This may be done best by compressing and cooling the air, 25 to 30 lb. gage pressure being used at the compressor, although only 12 to 15 lb is required at the air nozzle.

Safety Work in Ice Plants

DETAILS THAT ARE APPARENTLY OF LITTLE IMPORTANCE OFTEN CAUSE MORE ACCIDENTS THAN THE SELF-EVIDENT HAZARDS. BY GEORGE STEERS, JR.*

ACCORDING TO the statistics of the various compensation insurance companies, 30 per cent of all accidents in our industry occur in our plants. This is an especially large figure because it involves a relatively small number of men, whereas the other features of our business, which furnish the other 70 per cent of the accidents, employ a large number of men and they work the most of their time without direct supervision and do work which is of its nature much more hazardous than those who are working inside. The classification of accidents in which we are represented is as follows in decreasing importance: slipping and tripping, handling material, falling objects, protruding objects, hand tools, moving parts, repairs to machinery, fellow employes, cleaning machinery, operation of machinery, steam burns, oiling machinery, firing boilers, explosions, cable breakage and defective wiring. From a study of this list, it is evident that the things we think of as having the most possibilities for hazard in an ice plant are less dangerous than those things so small and insignificant as to appear of little consequence.

DEFECTIVE EQUIPMENT CAUSES SERIOUS ACCIDENTS

When we think of accidents in an ice plant we most often think of those caused by defective equipment, because injuries resulting from such accidents are usually serious. Surely the modern plant operator will see that no money is spared to take every possible precaution against this type of accident.

It is presumed that a plant owner will surely see that all moving wheels, gears and shafts are properly guarded with railing, that the pulleys and belts and crank shafts are likewise guarded, that all platforms, stairways and pits have railings around them and that the switchboards are properly closed off, with a rubber mat in front of them.

Twenty-seven per cent of our total accidents in ice plants are due to slipping and tripping. It is not possible to have dry floors in an ice plant and wet ones are always slippery. It is not possible always to have the floor of the ice storage room free from small pieces of ice, nevertheless, with proper attention, both of these hazards can be minimized. The hazard of slippery floors in the ice storage can be almost completely removed by the use of half oval hardwood strips nailed on top of the regular plank floor and spaced about 1½ in. apart. These should be laid so the ice is dragged across them most of the time. This gives the man handling ice in the storage room a secure footing on which he can brace himself, one that is never wet or icy and one on which the small pieces of ice will not stay. They roll down into the cracks and if the store room is swept daily the danger of accidents due to a slippery floor are practically removed. The hazard that wet floors produce can be largely remedied if the floors are kept free from oil or any other greasy substance and also if the men working on them are not allowed to wear rubbers, boots or shoes with rubber soles, leather soled foot gear being the most practical for this purpose even though the men's feet become wet. They are less likely to slip when working on leather.

Falling objects and hand tools cause many accidents and in many cases the tools themselves are unsafe for use. It is just as important that the tools available for work around an ice plant be safe tools as it is to provide any tools at all, and an unsafe tool is a deliberate intent on the part of those in charge to force the workmen to take chances they should not take.

LACK OF KNOWLEDGE RESULTS IN FREQUENT ACCIDENTS

The things causing most accidents are the little things which through our own neglect and the man's lack of knowledge cause frequent small accidents which incapacitate him partially or totally for a short period of time. Probably the most of our difficulties can be laid to what safety men call "poor housekeeping" around our properties. If we would take the time, expense and trouble to keep our properties in a neat, clean manner, that in itself would probably reduce our accidents in a large percentage. A clean, neat plant attracts a better class of men to work in it than one which is allowed to be run in a slipshod manner and is dirty throughout.

VALUE OF GAS MASK IS OVER-ESTIMATED

Use of gas masks in an ice plant is emphasized to a great extent by all state inspectors and inspectors for insurance companies. In the writer's opinion, the value of a gas mask in an ice plant is considerably over-estimated. Either it is out of order, or the men are not using it often enough to be familiar with its proper use quickly so that a great part of its value is lost. Also, it is uncomfortable to work in and vision is exceedingly poor. In the majority of cases of ammonia leaks, engineers much prefer to use a rag or a sponge wet with water, if some immediate action is necessary which takes only a few seconds to perform. The time lost in hunting up the gas mask and putting it on not only would do the job but might make a minor task a serious one. We have found that in the case of bad leaks considerable work could be performed by the operator with a heavy towel wrapped around his face wet with vinegar and our men have preferred this to the use of the gas mask which is provided for them.

*Kalamazoo Ice & Fuel Co., Kalamazoo, Mich. Abstract of paper presented at 14th Annual Safety Congress, Cleveland, Ohio, Sept. 28—Oct. 2, 1925.

District Heating Rates for Various Conditions

BRIEF RESUME OF RATES OF SEVERAL COMPANIES, DISTRIBUTING BOTH STEAM AND HOT WATER, MAY SERVE AS GUIDE FOR DISTRICT HEATING ENGINEERS

TO THOSE interested in the production and distribution of district heating steam or hot water, the following tabulations of rates supplied by district heating plants throughout the country should prove of value. The figures are taken from an unusually complete list published in a recent issue of the Bulletin of the N. D. H. A. In making up this list, data were obtained from over 200 district heating plants. These data show the practice of various companies in making up their rates, together with several types of coal clauses and other modifying conditions. They were not reprinted in the Bulletin of the N. D. H. A. to be followed exactly in making up heating rates, but to serve only as a guide for those interested and a few of the rates are given below for the same purpose. Since conditions in different plants will necessarily vary, the rates should be read with this point in mind.

Atlanta, Ga. (Georgia Railway & Power Co.) Steam.

Minimum Guarantee: To and including 5000 sq. ft. of radiation on basis of 200 lb. of steam per sq. ft. of radiation per season, $125 per M. lb. condensation. All over 5000 sq. ft., $1.00 per M. lb.

First 10,000 lb. cond. per mo	$1.75 per M lb.
Next 10,000 lb. cond. per mo	1.55 per M lb.
Next 10,000 lb. cond. per mo	1.40 per M lb.
Next 20,000 lb. cond. per mo	1.20 per M lb.
Next 20,000 lb. cond. per mo	1.10 per M lb.
Next 30,000 lb. cond. per mo	1.00 per M lb.
Next 100,000 lb. cond. per mo	.90 per M lb.
Next 300,000 lb. cond. per mo	.80 per M lb.
Over 500,000 lb. cond. per mo	.55 per M lb.

as may be shown by the statement of the meter. Bills are due when rendered and a discount of 10 per cent will be allowed if bills are paid within 10 days after the due date shown on bills.

Atlantic City, N. J. (Atlantic City Electric Co.) Hot Water 30c per sq. ft. of required radiation.

Baltimore, Md. (Ashburton Steam Heat Co., Inc.) Steam.

First 10,000 lb. cond. per mo	$1.10 per M lb.
Next 10,000 lb. cond. per mo	1.05 per M lb.
Next 10,000 lb. cond. per mo	1.00 per M lb.
Next 10,000 lb. cond. per mo	.95 per M lb.
Next 10,000 lb. cond. per mo	.90 per M lb.
Over 50,000 lb. cond. per mo	.85 per M lb.

Baltimore, Md. (Terminal Freezing & Heating Co.) Steam.

First 100,000 lb. cond. steam	$1.75 per M lb.
Next 200,000 lb. cond. steam	1.44 per M lb.
Over 300,000 lb. cond. steam	1.10 per M lb.

The foregoing rates to be subject to a discount of 5 per cent on all monthly bills when paid strictly on or before the tenth day of each month following that in which service shall have been rendered. In addition, an annual readiness-to-serve charge to be computed at the rate of 7c per sq. ft. of connected radiation.

Birmingham, Ala. (Birmingham Railway, Light & Power Co.) Steam Rates.

Said steam so furnished shall be measured as condensed steam by the company's meter or meters, on the premises, and the consumer agrees to pay the company for said steam so furnished and measured as aforesaid, monthly within 10 days of the rendition by the company of bill therefor at the following monthly rates:

First 10,000 lb. steam, or part	$1.10 per M lb.
Next 10,000 lb. steam, or part	1.00 per M lb.
Next 10,000 lb. steam, or part	.90 per M lb.
Next 20,000 lb. steam, or part	.85 per M lb.
Next 20,000 lb. steam, or part	.80 per M lb.
Next 30,000 lb. steam, or part	.75 per M lb.
Over 100,000 lb. steam	.70 per M lb.

Discount—Each bill rendered for said steam so furnished shall be subject to the following quantity discount based on monthly consumption, to-wit: 10 per cent when consumption is less than 101,000 lb.; 15 per cent when consumption exceeds 101,000 lb. and not exceeding 250,000 lb.; 20 per cent when consumption exceeds 250,000 lb. and not exceeding 500,000 lb.; 25 per cent when consumption exceeds 500,000 lb. and not exceeding 750,000 lb.; 30 per cent when consumption exceeds 750,000 lb.

Each bill rendered for such steam furnished shall be subject to an additional discount of 5 per cent if paid at the office of the Company within 10 days after the rendition thereof.

Boston, Mass. (Edison Electric Illuminating Co.) Steam.

All flat rates have been discontinued and the seasonal rate for steam service payable during the season is as follows:

First 50,000 lb. per mo	$1.30 per M lb.
Next 50,000 lb. per mo	1.20 per M lb.
Next 100,000 lb. per mo	1.00 per M lb.
Next 300,000 lb. per mo	.90 per M lb.
Next 500,000 lb. per mo	.80 per M lb.
Over 1,000,000 lb. per mo	.75 per M lb.

If in any month the average cost of coal used by the company in its steam service stations exceeds $3.75 per long ton in the bunkers, an additional charge will be made, computed as follows: The number of long tons of coal used for all steam service during the preceding 12 months will be divided by the number of thousand pounds of steam sold (whether measured by meter or estimated) during the same period; the quotient being the average amount of coal required for each 1,000 lb. of steam sold, will then be multiplied by the cost of coal in excess of $3.75 per long ton for the month in question, and the product will be the additional charge per thousand pounds of steam.

A minimum charge will be made of $5.00 per mo. per meter unless otherwise provided.

Yearly guarantee rate for steam service: The customer agrees to install a pumping system approved by the company for the return of the condensation to the company's return mains without payment of $120; and in consideration thereof the company agrees that a deduction of 5c per thousand pounds will be made from the prices stated. A minimum charge will be made of $5.00 per month per meter unless otherwise provided.

Battle Creek, Mich. (Consumers Power Co.)

First 10,000 lb	$1.50 per M lb.
Next 90,000 lb	1.40 per M lb.
Next 400,000 lb	1.20 per M lb.

Next 1,500,000 lb..... 1.00 per M lb.
Over 2,000,000 lb..... .90 per M lb.

Discount—10 per cent. Minimum Bill—2c net per month per sq. ft. of required radiation.

Boone, Iowa. (Iowa Railway & Light Co.) Hot Water.

First 100 sq. ft. or less radiation.....$65.00
Next 400 sq. ft. of radiation, per sq. ft..... .51
Next 500 sq. ft. of radiation, per sq. ft..... .49
Next 500 sq. ft. of radiation, per sq. ft..... .47
Over 1500 sq. ft. of radiation, per sq. ft..... .45

Chicago, Ill. (Illinois Maintenance Co.)

Base Rates

Up to and including 10,000 lb. per mo....$2.00 per M lb.
Over 10,000 and up to 20,000 lb..... 1.60 per M lb.
Over 30,000 and up to 60,000 lb..... 1.30 per M lb.
Over 60,000 and up to 100,000 lb..... 1.00 per M lb.
Over 100,000 and up to 200,000 lb..... .90 per M lb.
Over 200,000 lb..... .85 per M lb.

10 per cent discount on base rate. Coal and labor surcharge 23c per 1000 lb.

The foregoing base rates are fixed upon an assumed average cost of coal delivered to all the plants of the company of $4.00 per ton and an average cost of all plant labor of 50c per man per hour. As such cost of coal or such cost of plant labor or both, shall increase, the rates above specified shall increase, and as such cost of coal or such cost of plant labor, or both, shall decrease, said rates shall decrease as follows: For each 10c increase or decrease in such average cost of coal per ton in any month, 1c per 1000 lb., without the discount provided for in paragraph 3 hereof, shall be added to or deducted from, as the case may be, the net base rates above specified in the bill for service hereunder for such month; and also for each 3c increase or decrease in such average cost of plant labor per man per hour in any month, 1c per thousand lb., without the discount provided for in paragraph 3 hereof, shall be added to or deducted from, as the case may be, the net base rates above specified in the bill for service hereunder for such month.

Columbus, Ohio. (Columbus Railway, Power & Light Co.) Hot Water.

Fifteen cents per season per sq. ft. of radiating surface required, as determined as follows: To the cubic contents of the enclosure to be heated, added 75 times the sum of the glass and door surfaces and the quotient of the exposed wall surface divided by the proper ratio from the table below; one-hundredth of this sum is the area of radiating surface required.

Table of Ratios

First class brick construction with 12 in. walls..... 12
Second class brick or first class frame construction well protected 10
Second class frame construction unprotected..... 8

Detroit, Mich. (The Detroit Edison Co.) Steam.

Rate for October, 1922

First 100,000 lb. steam or less as metered per month .....$1.30 per M lb.
For supply in any month in excess of 100,000 lb. .....$1.00 net per M lb.

Subject to 10 per cent discount for prompt payment.

DeKalb and Sycamore, Ill. (Illinois Power Co.)

Service Charge

Size A or No. 2 Meter.....$16.00 per season
Size B or No. 3 Meter..... 18.00 per season
Size C Meter..... 20.00 per season
Size D Meter..... 22.00 per season

Steam Charge

First 25,000 lb.....$0.90 per M lb.
Over 25,000 lb..... .80 per M lb.

Grand Rapids, Mich. (Hodenpyl, Hardy & Co.) Low Pressure Steam.

First 10,000 lb.....$1.35 net per M lb.
Next 90,000 lb..... 1.26 net per M lb.
Next 400,000 lb..... 1.08 net per M lb.
Next 1,500,000 lb..... .90 net per M lb.
Over 2,000,000 lb..... .81 net per M lb.

Kansas City, Mo. (Kansas City Power & Light Co.) Steam.

Metered Service

Available for those consumers whose minimum consumption of steam during any one month of a calendar year is not less than 1/6 of the maximum consumption of steam during any month of the same calendar year.

Consumer's consumption of steam shall not be less than 15 million pounds, per yr. and if the consumer does not use a total of 15 million pounds, then an adjustment of the monthly billing charges for the year shall be made by increasing the monthly consumption proportionately so that the total amount of steam for which the consumer is billed totals 15 million pounds.

First 50,000 lb. cond. per mo.....$1.50 per M lb.
Next 50,000 lb. cond. per mo..... 1.40 per M lb.
Next 100,000 lb. cond. per mo..... 1.30 per M lb.
Next 300,000 lb. cond. per mo..... 1.20 per M lb.
Next 300,000 lb. cond. per mo..... 1.10 per M lb.
Next 400,000 lb. cond. per mo..... 1.00 per M lb.
Next 800,000 lb. cond. per mo..... .95 per M lb.
Next 1,000,000 lb. cond. per mo..... .90 per M lb.
Over 3,000,000 lb. cond. per mo..... .85 per M lb.

Subject to a penalty of 10 per cent when payment therefor is not made on or before the 10th day after day of bill. Minimum charge of $400.00 per mo. for twelve continuous months. It shall be optional with Company to supply either High Pressure, Low Pressure, or both classes of service in order to supply steam at this rate.

La Crosse, Wis. (Northern States Power Co.)

Rate should be 19 cents per sq. ft. of radiation required per season.

Lansing, Mich. (Board of Water & Electric Light Commissioners.) Steam.

First 200,000 lb. used per mo.....$1.10 per M lb.
Next 800,000 lb. used per mo..... 1.00 per M lb.
Over 1,000,000 lb. used per mo..... .85 per M lb.

Discount—10 per cent if paid by the 15th of the month in which the bills are presented.

Pontiac, Ill. (Public Service Co. of Northern Illinois.) Steam.

First 20,000 lb. cond. per mo.....$0.80 per M lb.
Next 30,000 lb. cond. per mo..... .70 per M lb.
Next 50,000 lb. cond. per mo..... .60 per M lb.
Next 100,000 lb. cond. per mo..... .55 per M lb.
Over 200,000 lb. cond. per mo..... .50 per M lb.

Prompt Payment Discount: 5 per cent will be allowed upon all bills paid on or before the 10th day following the date of their rendition.

Reading, Pa. Steam.

The charge for heat will be at the rate of $1.10 per 1,000 lb. of condensation, subject to the following discounts, if bills are paid on or before the 10th of the following month: 5 per cent on consumption of less than 200,000

lb. cond. per mo. 10 per cent on consumption of 200,000 lb. cond. and over per mo. Minimum monthly charge—$4.00.

St. Louis, Mo. (Union Electric Light & Power Co.) Steam.

Low Pressure Service

(a) Radiation charge: For each square foot of radiation, 6.75c per season, payable in the months of September to May, inclusive, at the rate of ¾c per sq. ft. per month.

(b) Condensation Charge:

First 25,000 lb. per mo.	$1.15 per M lb.
Next 50,000 lb. per mo.	1.05 per M lb.
Next 125,000 lb. per mo.	.90 per M lb.
Next 300,000 lb. per mo.	.80 per M lb.
Over 500,000 lb. per mo.	.65 per M lb.

(c) Additional Charge for Exposed Delivery: The foregoing condensation charge shall be increased 15c per M lb. for steam which has been exposed to condensation loss in distribution mains. Minimum monthly bill shall be the monthly installment of the season's radiation charge, provided no monthly bill shall be less than $5.00 net.

High Pressure Service

First 15,000 lb. per mo.	$1.40 per M lb.
Next 35,000 lb. per mo.	1.25 per M lb.
Next 75,000 lb. per mo.	1.10 per M lb.
Next 375,000 lb. per mo.	1.00 per M lb.
Next 500,000 lb. per mo.	.90 per M lb.
Over 1,000,000 lb. per mo.	.80 per M lb.

Additional Charge for Exposed Delivery: The foregoing charge shall be increased 15c per M lb. for steam which has been exposed to condensation loss in distribution mains. Minimum Monthly Bill shall be $10.00 net.

Condensate Not Returned

The foregoing rates are based on the return of condensate to the company's return mains near the point of delivery of steam to the customer. In cases where the condensate is not so delivered to company under proper pressure for return, the foregoing charges will be increased 4c per M lb. of condensate.

Over 700,000 lb. per month. $0.66 per M lb.

10 per cent discount for prompt payment. No. of customers—226. Feet of main—16,604.

St. Paul, Minn. (Northern States Power Co.) Steam.

First 40,000 lb. cond. per mo.	$1.40 per M lb.
Next 40,000 lb. cond. per mo.	1.30 per M lb.
Excess	1.20 per M lb.

Discount—10 per cent.

Toledo, Ohio. (Toledo Edison Co.) Hot Water.

Rate for the Season

First 500 sq. ft. or fraction.	$.55536 per sq ft.
Next 500 sq. ft. or fraction.	.50904 per sq. ft.
Next 500 sq. ft. or fraction.	.49356 per sq. ft.
Next 500 sq. ft. or fraction.	.44808 per sq. ft.
Next 500 sq. ft. or fraction.	.41676 per sq. ft.
Next 3,000 sq. ft. or fraction.	.41676 per sq. ft.
Over 5,000 sq. ft. or fraction.	.38640 per sq. ft.

Winnipeg, Canada. (City of Winnipeg Hydro Electric System.) Steam.

Open Order Rate

For temporary or special steam service, $2.00 per M lb. of condensation.

Season Rate

For continuous use during the heating season:

First 25,000 lb. of monthly total or part.	$1.40 per M lb.
Next 50,000 lb. of monthly total.	1.20 per M lb.
Next 125,000 lb. of monthly total.	1.10 per M lb.
Next 300,000 lb. of monthly total.	1.05 per M lb.
Over 500,000 lb. monthly.	.90 per M lb.

Subject to a discount of 5 per cent for payment of bill on or before discount date. Heating Season—September 1 to May 31.

Steam Generator of Unique Design Gives High Rating

COMBINING the recent developments of pulverized fuel, the water-cooled furnace wall, preheated air and turbulent action in the combustion space, the Combustion Steam Generator recently placed on the market forms one of the most interesting developments that have thus far occurred in steam boiler practice.

In this generator, practically all the boiler surface is exposed to radiant heat. The application of pulverized fuel firing to the design permits the elimination of the large furnace, with its refractory surfaces, water screens, side wall screens and the like, required with existing types of boilers.

This steam generator unit, produced by Combustion Engineering Corp., consists of a furnace, the walls of which are composed of tubes of the fin type, all exposed to radiant heat.

Pulverized fuel is introduced through burners in four corners and burned in a turbulent condition in the form of a vortex, because the primary mixture of fuel and air, as well as the highly preheated secondary air, enter tangential to an imaginary circle. The flame and gases descend through a multi-tubular water screen into a settling chamber, where the ash is deposited; the gases flow through a superheater, thence through an air preheater to the stack or to the induced draft fan.

In the Combustion Steam Generator a definite circulation is established. Water fed to the main drum descends through the outside circulating tubes to the lowermost drum; from this drum it passes through the vertical fin tubes forming one wall of the combustion chamber to the lower of the upper drums, from there through the connecting tubes forming the roof of the furnace into the main drum. The lowermost drum also supplies water to the bottom water screen and the other connecting drum, from which it passes through the vertical fin tubes into the main drum. The horizontal headers for the remaining two side walls, as mentioned before, are also connected to the lowermost drum, receiving their water supply from this drum and discharging into the upper headers which in turn are connected to the main drum.

This unit is designed to be installed in from one-half to two-thirds the space required for present-day boiler units to produce the same amount of steam and to effect a great saving in labor, construction cost and real estate investment.

At the steel mills of Taylor Bros. in England, a steam generator of the above type has been operating for some time. It has a total heating surface, including the fins of 1977.5 sq. ft., with 2556 cu. ft. of combustion space. It was designed to produce 100,000 lb. of steam, working at about 1500 per cent of rating. When evaporating 70,000 lb. of steam, equivalent to about 1200 per cent of rating, an efficiency of 88 per cent was obtained.

Improvements at the Miami Paper Co.

Motors Being Installed to Replace Steam Engines and Electric Machines Are Being Changed from 25 to 60 Cycles

POWER DEVELOPMENTS at the plant of the Miami Paper Co., near Dayton, O., are extremely interesting in that they have had a far reaching effect upon the operation of the entire mill. As originally installed, the paper machines were driven by steam engines, and what alternating current was used was supplied at 25 cycles and was purchased from the local traction company. The old boiler house equipment consisted of a number of Stirling boilers, each rated at 300 hp. and stoker fired. These boilers were 22 yr. old and as might be expected, were not properly set to obtain efficiencies in accordance with present day requirements.

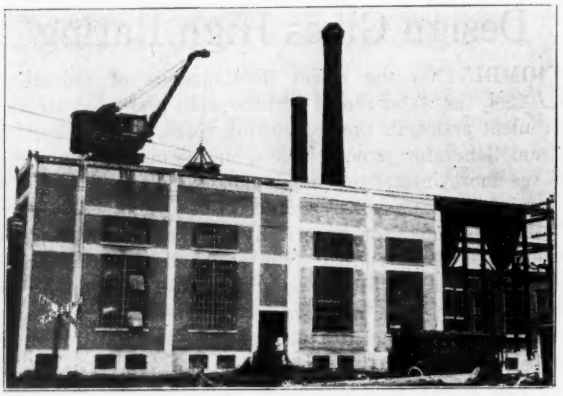


FIG. 1. COAL HANDLING CRANE OPERATES ON THE ROOF OF THE BOILER HOUSE

In 1918 the steam demand had reached the point where it became imperative to install two Stirling boilers, each rated at 750 hp. and fired by Taylor stokers. These boilers were designed for four passes of the gas and the breeching was accordingly placed below the operating floor. This breeching is of reinforced concrete and is unlined. The boilers were equipped with Babcock & Wilcox superheaters to operate at 175 lb. gage pressure and to give a superheat of 125 deg. F.

The stokers are driven by individual American Blower Co. engines, which are so arranged that one engine can drive both stokers. Three Buffalo Forge Co. forced blast fans were installed. They are driven by Terry turbines and the ducts are interconnected, so that any two fans may be used to carry the load and the third unit held as a spare.

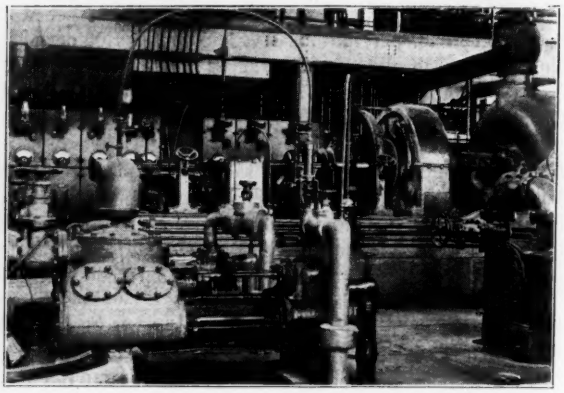


FIG. 2. INTERIOR VIEW OF ONE END OF OF THE OLD TURBINE ROOM

Ash pits are of reinforced concrete and are unlined. The ash is dumped into industrial cars and pushed along a track to a platform elevator which elevates the car to the level of a track running over the concrete ash bin, which is located at the west end of the building. With this arrangement the ash can be dumped at any point in the bin. The spouts from this bin are at a sufficient height so that at some time in the future a rack can be constructed beneath them and the ash unloaded directly into railroad cars. At the present time, the ash is sold and carted away in motor trucks.

Coal handling was arranged for in an unusual manner, in that railroad cars are shunted to a track at the side of the building. A McMyler Interstate Co. locomotive

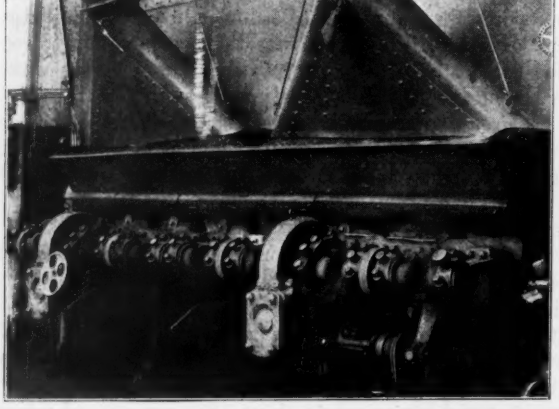


FIG. 3. THESE FLARED COAL SPOUTS DID NOT PROVE SATISFACTORY

FIG. 4. HINGED SPOUTS HAVE PROVEN TO BE BETTER THAN THE FLARED TYPE

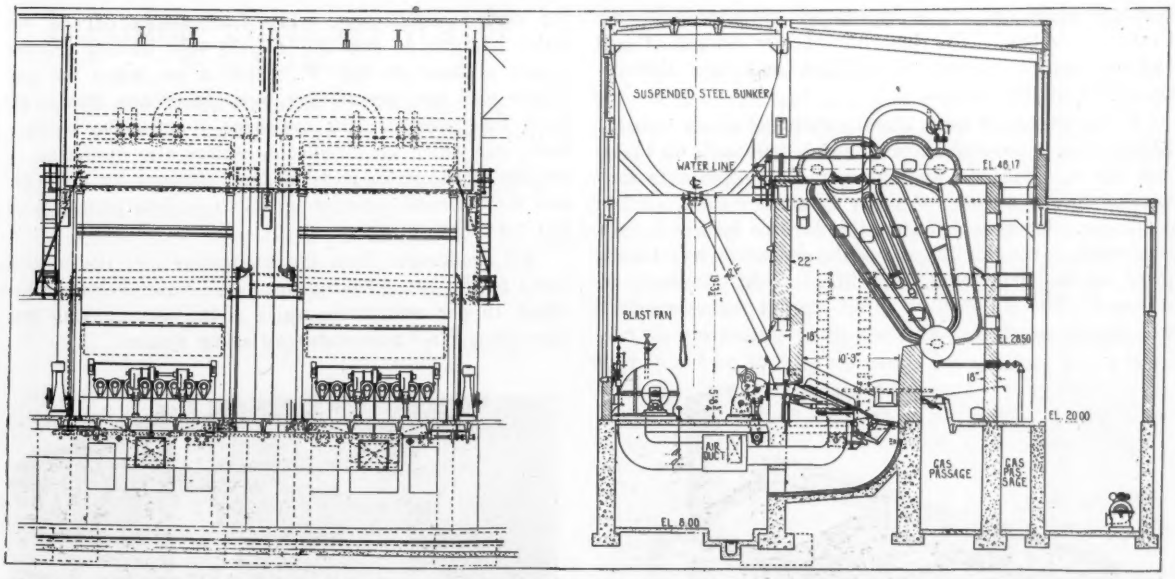


FIG. 5. BOILERS ARE BAFFLED FOR FOUR PASSES OF THE GAS AND THE BREECHING IS BELOW THE OPERATING FLOOR

type crane is mounted on a track above the boiler house steel coal bunker which stores about 200 T. at each boiler. The crane bucket of 1½ T. capacity, is dropped over the side of the building and unloads directly from the coal car to a crusher which is mounted on a truck which operates on the same track with the crane. With this arrangement it has been found possible to unload all but about 1 T. from the car without any hand shoveling and a car can be unloaded in about 30 min.

To unload the car completely it is switched to a 12,000 T. reinforced concrete coal pocket where it is dumped. This coal pocket can be flooded if required. A McMyler-Interstate locomotive crane is used to reclaim the coal from this pocket. The coal used at present is from the Kentucky fields and averages about 14,000 B.t.u. as fired. An interesting and economical use made of the crane on the boiler house roof is that it was used to erect the steel for the extension to the boiler house. The stack which serves the new boilers is of reinforced concrete, is unlined and measures 225 ft. in height and 11 ft. in diameter.

Importance of the foregoing is that the general features of design used in the installation of these two Stirling boilers more or less set the standards by which additions to the plant would have to be made. This was the situation when in 1924 H. S. Taylor, consulting engineer, undertook to solve the power problem at this paper mill. The most recent changes to the boiler house consist of the installation of two Stirling boilers, each rated at 778 hp. They are fired by Taylor stokers and are equipped with Babcock & Wilcox superheaters. Two Sturtevant forced blast fans, driven by Terry turbines, have been installed and interconnected with the old units. Either of these fans will carry two boilers. A third Stirling unit similar to the above has been erected. In all probability no more fan units will be required.

Feeding Coal to Boilers

Flared coal spouts were used on the first two stoker units. They did not work satisfactorily, however, because of stratification of the coal so the new units each have two round spouts which are hinged and they have proved to be much more satisfactory.

Miscellaneous boiler house equipment consists of Mason regulators on the fan turbines, Copes feed water regulators, Yarway and Everlasting blowoff valves, Craig system damper regulators and General Electric Co. flow meters on the first two units and Bailey boiler meters on the remaining three units. The pipe was all made by the

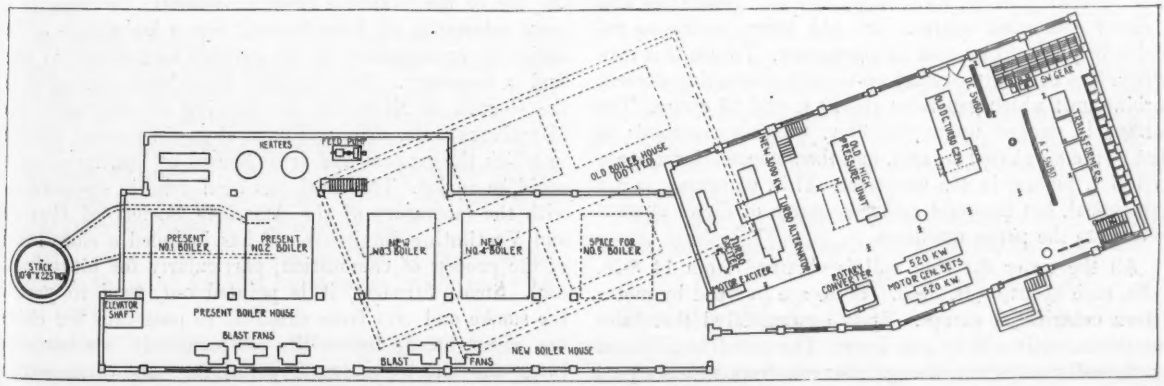


FIG. 6. OLD BOILERS HAD TO BE TORN OUT AND NEW EQUIPMENT INSTALLED WITHOUT INTERRUPTING SERVICE

National Tube Co. It is Vanstoned and equipped with Crane Co. valves. The feed pumps now consist of one DeLaval turbine driven centrifugal and two Epping-Carpenter duplex pumps.

In the generator room there is installed a new General Electric Co. turbo-alternator rated at 3000 kw., 60 cycles and 440 v. This is a high pressure unit, operating condensing by the use of a Wheeler Engineering Co. surface condenser. Steam is bled from this turbine for use in process work. The old 25-cycle turbo-generator remains in place for the time being, but will no doubt eventually be scrapped. The old 750-kw. direct-current turbo-generator will remain in service. This is a mixed pressure unit, taking what auxiliary steam is not used by the feedwater heaters. This is an interesting unit in that two d.c. generators are mounted on the turbine shaft.

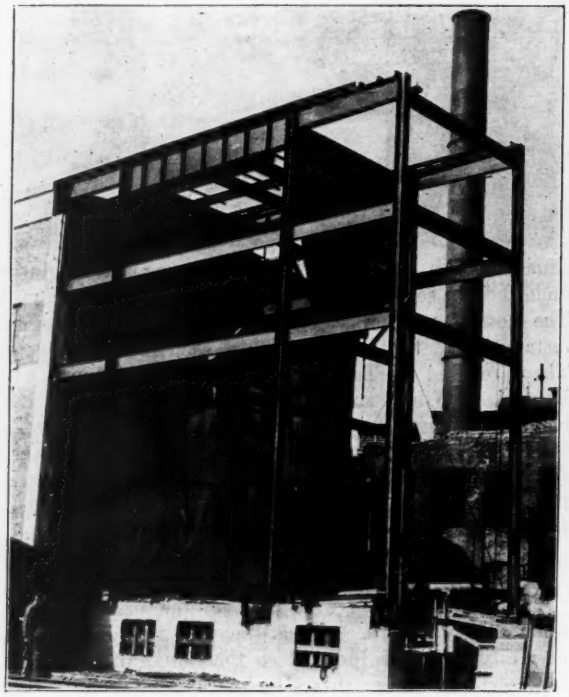


FIG. 7. NEW BOILER HOUSE STEEL WAS PLACED BY THE COAL HANDLING CRANE

In this room are also two 750-kw. motor-generator sets, each consisting of an a.c. motor, two d.c. generators and a direct connected exciter. The old rotary converter remains in place, to be used in emergency. To use this converter, it is necessary to start up the old alternating-current turbine unit which generates at 440 v. and 25 cycles. The voltage is stepped up to 33,000 v. which corresponds to that of the purchased current, and then stepped down again to 185 v. for use in the converter. This, of course, is not economical, but it would assure a source of direct current to operate the paper machines.

All the water for this mill is obtained from 14 8-in. wells, each about 60 ft. deep. These are pumped by motor driven centrifugal pumps. It is contemplated that later two 60-in. wells will be put down. The water is delivered by the well pumps to a storage reservoir from which a part of it is picked up by circulating pumps and passed through the surface condensers. The temperature of the well water is about 56 deg. F., whereas that leaving the condenser is about 80 deg. F., which is too warm for some of the mill use, accordingly separate pumps draw water from the reservoir and discharge it into the overhead tank, into which the circulating pumps also discharge. A portion of the water is taken from between the condenser and the overhead tank for use in those departments which can use the warm water.

All condensate from the condensers and the mill returns to the two 3000-hp. open feed-water heaters where about 15 per cent make up is added after having gone through a We-Fu-Go water softening system.

FIG. 8. TEMPORARY STEAM HEADER EXTENDS FROM THE BOILER HOUSE TO THE TURBINE ROOM

The building construction is of steel encased in concrete and brick filled walls. The roof is a poured concrete slab which is waterproofed with Johns-Manville composition roofing.

The operation of this plant is under the supervision of Joe McNabb, chief engineer of the Miami Paper Co.

THE RELATIVE THERMAL efficiency and the economy in the use of the available fuels in domestic furnaces is of great interest to all householders; also a knowledge of the design or arrangement of the furnace best suited to each fuel is necessary. Investigations have been conducted by the Bureau of Mines on the burning of anthracite and bituminous coals, coke, and natural gas in a small furnace in which the amount and arrangement of heating surfaces could be varied. This work has been done in co-operation with the laboratory of the American Society of Heating and Ventilating Engineers. It has included a close study of the process of combustion, particularly for bituminous coal. Small furnaces, it is pointed out, tend to permit the smoke and tars from this fuel to pass into the chimney unconsumed, due to the comparatively low temperatures and short gas travel pertaining, and thus reduce the efficiency and contribute to the smoke nuisance.

Running Them on Water

By W. L. Johnson

IN A SMALL central station of 3000 hp. the "Old Man" sat in his chair and watched the turbine valves spit water.

He cussed softly to himself. It soon quit and he settled back to a more comfortable position.

"Remember, Bill, when No. 3 got knocked out for six weeks?"

He smiled at me and winked at Ed, my oiler.

"I'll tell the world—" I began.

"Tell it to Bud while I go and take a reading for you."

He rose and started for the board. "Bud" was an engineer from Montana finishing his last year on the "hill," and had dropped in to look us over.

"It was one Sunday morning. Ed and I were here talking, when No. 3 let out a report like a 12-in. gun that jarred the dust from the roof timbers. We had a light load, too much for the turbine and hardly enough for both the turbine and No. 3.

"As the turbine usually showed water before the engines got it, I was puzzled at first as to what to lay it to.

"Well I covered ground pretty fast and shut off No. 5 throttle first, as considerable noise could be heard somewhere inside the cylinders. Several more loud bangs shook No. 3 before I reached No. 6 throttle after opening No. 5 again. I shut No. 6 and all the noise seemed to stop.

Ed had gone to No. 1 and started her rolling. He soon brought her up to speed and I put in the plugs to synchronize. No. 3 was running quietly and up to speed, due to the turbine dragging her along.

"I slapped No. 1 in the load and dumped No. 3. As she rolled to a stop, I felt around for hot bearings and found the crosshead on No. 6 side warm and the main bearing so hot you couldn't bear your hand on it.

"As these engines turn 155 r.p.m., you cannot run with hot main bearings; so we feel around every 15 min. and I had found No. 3 cool all along.

"The 'Old Man' was home, so I called him up. He ordered the covers off, as he thought the valves were gone. Ed and I got the cover off No. 6 and found the valves, both cutoff and main valve, unharmed."

It might be well to mention that in this plant were three generators of 450 kw., tandem driven, and a turbine of 750-kw. capacity. As we furnished steam to the salt plant across the way on the lake shore it was a hard drag sometimes.

The boilers consisted of seven 280-hp. vertical and two 500-hp. horizontal water-tube boilers. The former were served by hand fired dutch-oven furnace and hand regulated and it took a pretty good water-tender to keep them steady. The horizontal boilers were equipped with chain grate stokers. In spite of two separators in the engine room we would get water and the old slide-valve engines (non-condensing) would swim in it.

As this was a 24-hr. service station, it made things snappy for the gang and the boiler house outfit would get bawled regularly.

Bud looked interested, so I went on with my story.

"The 'Old Man' came down right away before we got No. 5 cover off. Her valves were O. K., so we took the cylinder head from No. 6 and when we got it off the 'Old Man' had a fit.

"The big piston was clean gone except a small portion on the rod and the pieces were small enough to put in your pocket. The stroke is 33 in. and the pistons are 22-in. diameter, so you can see what an awful smash it must have got.

"Well, we worked all night to fit another piston and when morning came were were all ready to try it out, when I found the crank disk on No. 6 side cracked from the crankpin to the main shaft and started to crack through to the rim.

"We got busy and hooked in with a station farther down the lake to help us carry the load, as No. 2 was down for repairs.

"To make a long story short, we decided to shrink a wrought-iron band on the disk and, after three attempts, were successful.

"But our troubles were not over yet, as the crankpin had to be re-located diametrically opposite the old hole and this took considerable time to bore and refit the pin. Then we cut a rocker arm in two to reverse the valve gear and welded it together again opposite its former position. The crankpin hole went through the counterbalance side of the disk, understand, so this necessitated counterbalancing all moving parts over again, which we accomplished by pouring a thousand pounds of lead in a form made for the purpose and afterward bolting through in four places to keep it from coming out sideways.

"A bet of $50.00 was made that this engine would not run again, and that it would go out in the lake."

The "Old Man" smiled as he threw the pad on the desk and dropped back into his chair again.

"That wasn't all, though," he remarked, "for we had to pull out the cheek blocks and the bottom block and rebabbit them on No. 6. This took us another ten days. Then I set the valves (we had Corliss exhaust valves on the engines) and took a couple of cards off of her. On the following Saturday night we put her in the load and she ran like a top."

Bud turned to go.

"This will make a dandy story to tell the boys, all right," he said.

He pulled out the cigars and we all lit up. The old man pointed toward the turbine which began to spit water.

"You won't see that next week. We're putting feed water regulators and a new boiler feed pump in the new house and the old vertical boilers will be equipped with the same. Also a water softener will be installed, as our feed water is unclean and full of lime."

Bud nodded and stepped out the door.

"You cannot run them on water when they are made for steam, can you, old timer?" He grinned at me and swung off up the road.

The Chief snorted. His white hair stood up like a cormorant's crest.

"Run them on water—" he bawled after Bud. "Why, demnit, that's all we've been doing for the last ten years!"

Excessive temperature of fuel oil at the burner results in gasification of the oil and puffing of the flame. Too low a temperature of the oil results in incomplete atomization and consequent incomplete combustion.

Trouble Shooting in D. C. Motors and Generators

SOME TIME ago, there appeared in these pages an article by Charles G. Green on "Trouble Shooting in D. C. Motors and Generators.* This article covers in an elementary and understandable manner some general methods for making tests on electrical equipment to locate faults. The general description covers tests which can be readily made and are theoretically correct; there are, however, certain inherent difficulties involved in making such tests

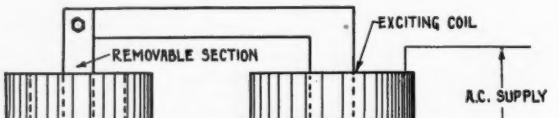


FIG. 1. METHOD OF TESTING FIELD COILS

which may cause the actual results to be somewhat uncertain and upon which a few comments may not be out of place, without intending in any way to criticize the article.

A short-circuited field coil may be tested us shown in Fig. 1 in Mr. Green's article but should the individual field coils be of a low resistance the actual voltage drop across each field coil will be low and should the short circuited portion of the coil be a small portion of the total, say a few turns there will be but a slight difference in the voltage drops across the coils. These comments are particularly applicable to a low voltage generator of reasonable capacity. The short-circuited coil may be observed by noting any induced sparking, which is caused by the unbalanced magnetic condition due to the weaker magnetic field at the pole excited by the short-circuited coil. To be absolutely certain that a particular field coil is short-circuited in any degree after the preliminary test, as described in the article, has been made, the coil should be removed and tested as shown in Fig. 1.

The field coil under test is placed in the magnetic circuit as shown and the yoke is excited from an a.c. source through a fixed coil. The coil under test acts as the secondary of a transformer and the induced electromotive force results in a certain voltage between turns which will cause current to flow between turns. The actual effect therefore will be evidenced by the smoking of the coil and will leave no doubt as to the location of the trouble.

To find short circuits in armatures, a test similar to the foregoing may be applied in a modified way. In fact, this is a test used by manufacturers of electrical apparatus on finished armatures as well as in electrical repair shops. This test equipment is generally known under the name of "growler." It is applied for testing purposes as shown in Fig. 2.

When a.c. excites the yoke the transformer effect generates or induces an electromotive force between armature turns, which causes current to flow between turns and is evidenced by smoke. The ends of the test yoke are

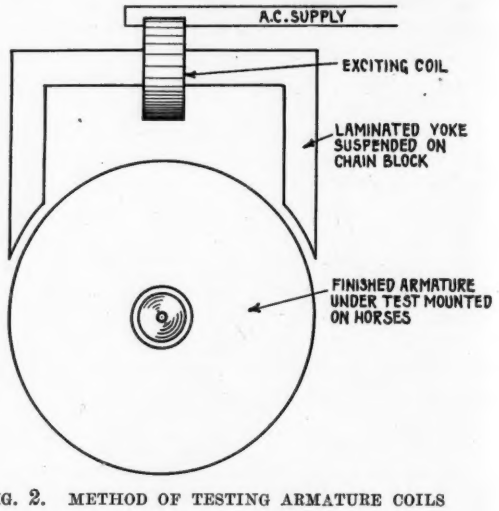


FIG. 2. METHOD OF TESTING ARMATURE COILS

usually slightly rounded and the armature is turned after a test is made so that the complete winding will receive a thorough test.

The foregoing tests are complete and are rigorous enough to show the minutest short circuits and may in fact clear up short-circuits caused by copper burrs or fins which are quickly burned off.

Springdale, Pa. C. O. VON DANNENBERG.

Common Sense Needed for Pipe Fitting

RECENTLY a friend who was visiting me, gave me an account of an incident which took place in the shops of a large automobile concern in Chicago. My friend being a millwright in this plant, the foreman of the maintenance gang asked him one day to assist a steam fitter in installing a steam heating coil in the lumber storage room.

Being located below the level of the steam header, the steam coils were unable to drain by gravity and when the work was nearly completed my friend noticed that no provision had been made to drain the coil as the end was closed with a cap. He immediately inquired of the steam fitter what his intensions were with respect to draining the condensate. The steam fitter argued that no drain was necessary but, not understanding how the system could operate without any provision for draining, my friend

went to the foreman who, after brief consultation with the steam fitter, peremptorily ordered that the coils be installed as originally planned.

When the work had been completed, the steam was turned on and the coil appearing to function properly, steam was left on over night. When in the morning my friend and the steam fitter returned to observe the manner in which the coil was operating, they found five of the pipes in the coil broken.

The lumber storage building, being isolated from the main plant, was unable to receive any heat except from this heating coil. During the night it had gradually filled with condensate and had frozen. This evidence was sufficient to convince even a steam fitter that some means of draining the coil was necessary; consequently upon reinstalling the coil a small valve was placed on the end of the heating coil and allowed to remain partly open while the coil was in operation. No further difficulty has been experienced.

Riverside, Ill. A. H. WILLARD.

Bags in Boiler Shells Due to Lifting of Water

IN THE Dec. 15 issue, p. 1284, is expounded a theory to account for a bag in the bottom of the shell of a return tubular boiler. It is thought that bags are formed by the water "lifting" off the shell and, I presume, the plate instantly softened by the heat of the furnace and the pressure forcing out the metal. The question at once arises: Why does the stretch of the metal stop with the formation of a bag? If there is a tendency to stretch the metal in this manner then there would never be a bag formed but a rupture of the shell with every "lifting" of the water.

That there is a violent lifting, or spraying action at the surface of a body of water boiling into a region of lower pressure, is well known, but it would be hard to conceive the whole mass of water rising by any force that can exist between it and the boiler shell. To raise this body of water, there must be suddenly formed a large amount of steam on the shell following the sudden release of pressure at the surface of the water, which, on account of the transmission of the necessary heat of evaporation, would, I think, be a highly fanciful speculation.

In order that a bag be formed, the metal must be softened by approximately a red-heat. This would take considerable time. Anyone who has heated a steel plate in a forge fire would be hard to convince that the shell of a boiler can be heated to redness during the interval that the water can be imagined as hovering above the boiler bottom. If I should experience a bag in the shell of a boiler, I would attribute it to the generally accepted cause—foul surface.

Los Angeles, Cal. C. O. SANDSTROM.

ALTHOUGH Mr. Hussey mentions two cases where he says the boilers were bagged by the steam suddenly leaving the boilers and lifting the water, in my opinion when the water is pulled over with the steam it is only from the surface and it would be impossible to lift it off the sheet. Supposing the steam did momentarily lift the water off the sheet, what would prevent the water in the boiler from instantly flowing to this particular spot?

When a boiler bags I have always found it to be due to mud or scale, or both, piling up over the fire, or a faulty setting. If the bridge-wall is too high and forced draft is used, when the fires are forced it will have a blow-torch effect on the sheet over the fire, resulting in a bag. In 15 yr. of experience I have never seen a boiler bagged by the water lifting off the sheet.

Toledo, Ohio. RALPH CUPPS.

MY THEORY of such an occurrence is that the sudden steam demand brought a quick reduction in pressure, allowing the water to evaporate rapidly enough to leave the boiler shell before the circulation could fill the space made by the rapidly escaping gas bubbles. This resulted in overheating the shell and the formation of a bag.

New Bedford, Mass. R. G. SPOONER.

WITH REFERENCE to the article in the issue of Dec. 15, p. 1284, I wish to state that I do not agree with Mr. Hussey's theory of bags in boilers. I have had 35 yr. experience in marine and stationary work, 12 yr. being devoted to boiler inspection.

We know that the sudden opening of a valve will cause the water to lift from the surface but not in a solid sheet entirely free from the bottom. I know of an instance on a steamer where one of the boilers was continually bagged but it was significant that there was always scale and sediment in the boiler sheet directly over the bag. This steamer had five boilers in a battery and it was found that the safety valve on the boiler which had bagged was the only safety valve in working order. The other four safety valves were overhauled and put in proper condition, all valves set to blow at the same steam pressure and no further trouble occurred.

A boiler shell bag is caused by scale or sediment collecting in at one point, usually over the grate. The scale and sediment prevents the water from conducting the heat away from the shell which soon becomes overheated and then the pressure in the boiler pushes the plate down forming the bag.

I have never seen or found a bag on the shell of a boiler where there was not a lot of scale or sediment at the point of bagging and in addition have noted the fact that these pieces of scale are standing on edge, closely packed together.

Evansville, Ind. B. SMITH.

I HAVE read the letter from F. E. Hussey, p. 1284, Dec. 15 issue, together with the editor's note, and am of the opinion that Mr. Hussey is mistaken in believing that the rapid opening of valves (as in the two cases he describes) was the reason for the bags forming in the boiler shells. I have personal knowledge of one case where the fireman informed his employer that the water had lifted in the manner described by Mr. Hussey.

I was asked to investigate and after the boiler was emptied of water, found considerable scale on the shell.

With 30 yr. experience in stationary power plant work, I have never seen a case of bag that was not due to scale, sediment or oil, either separately or in combination with other material. If it were possible for the rapid opening of a valve to lift all the water in a solid sheet, at any one point, then why does this not happen every time a spring loaded safety valve opens? My personal opinion, based entirely upon observation and experience is that a boiler with a sufficient amount of water and clean shell cannot be burned or overheated by the rapid opening of any large valve, unless the valve is left open long enough to lower

the water level below the fire line, in which case the top will be overheated not the bottom.

If it were possible for water to be lifted in this way long enough to permit the shell to become red hot, an explosion would probably result the instant the water returned to the shell. When a plate gets red hot because of scale or oil, no explosion results because the cooling is comparatively slow. As the scale cracks with the heat, the water does not reach the plate abruptly but only through the first fine cracks.

Of course the plate may be overheated and cooled slowly a number of times with no other damage than a slight crystallization but usually a bag will form.

Toronto, Canada. J. E. NOBLE.

I HOLD a first class engineer's license and have run engines and fired boilers for over 30 yr., during which time I have seen several boiler shells bagged but the cause was always oil, scale or dirt on the bottom of the shell.

I don't believe that the water would leave the shell on any return tubular boiler long enough for the shell to get hot, no matter how badly the boiler foamed.

A bag in a horizontal return tubular boiler is caused by the shell getting so hot that the plate becomes soft and stretches like a rubber balloon. The cooling action of the water above the scale is sufficient, however, to prevent the shell from rupturing. If the sudden rush of steam caused the water to leave the shell, it would not return until the safety valve had closed by which time the plate would be so hot that the contact of the water would cause an explosion which would rupture the plate.

Leominster, Mass. A. O. GATES.

Burning Out Motor Is Expensive

AFTER READING the interesting article in the Dec. 1 issue, page 1219, by W. F. Schaphorst, I would like more information as to the sort of protection against overloads provided for the motors in this particular installation. It seems that the protection is an important factor in the determination of the frequency of motor burnouts, and that in order to save the cost of rewinding, adequate protection should be provided. According to the figures, the average rewinding cost is $83.80, which is much less than the cost of first-class motor protection apparatus.

Schenectady, N. Y. D. C. HOFFMAN.

No effort is made in the large plant to which I referred to get overload protection. They protect only against a stalling current or short circuit. In some special cases they do differently but this is the general rule.

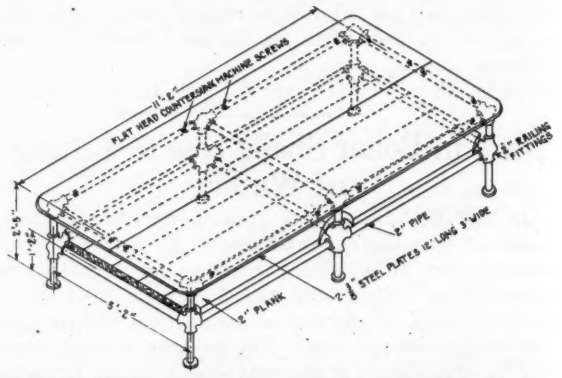
One of the most abstract problems facing the officials of every manufacturing plant is the cost of any breakdown —whether mechanical or electrical. Usually an electrical breakdown cost can be determined by determining the number of hours or days that electric motor or generator is out of service. In rewinding small motors of from ¼ to 10 hp., one can usually figure on 1½ to 2 days, while from 15 to 40 hp. would take 2 or 3 days and above this size would take 3 days to a week.

Any shop using a quantity of electric motors of various sizes should keep enough spare motors on hand to use as substitutes when one of the regulars is burned out or for some reason taken out of service. For example, two large automobile manufacturing concerns have standardized on certain motors of the so called "300 frame series." When a 10-hp. motor is burned out or the bearings become worn and need repairs it is taken off the rails and another motor of the same frame size put in its place, the machinery probably being tied up only 20 min. to ½ hr. Both companies have at least one spare motor of every frame size which they use throughout their plants.

Newark, N. J. W. F. SCHAPHORST.

Making a Servicable All-Steel Work Bench

OFTEN repair crews in the power plant are handicapped by lack of a suitable work bench. In most cases the bench is placed against the wall so that work can be done on one side only, thus limiting the number of men who can work effectively. The accompanying drawing shows an all-steel work bench, placed away from the wall, with all



ALL-STEEL WORK BENCH MADE FROM STANDARD RAILING FITTINGS

sides accessible. It is large and heavy but, if required, it can be moved with crow-bars.

The frame-work is made with 2-in. railing fittings and pipe, while the top consists of two ⅜-in. steel plates—12 ft. long and 3 ft. wide. These are held to the frame by 10½-in. by 4-in. countersunk head bolts, four on each side and two on the ends. A shelf on the lower cross-members is made with 2 by 12-in. planks. Repair parts and fittings may be stored here.

To facilitate repairs, there should be at least two machinist vises and one or two pipe vises. It may be convenient to place the pipe vises diagonally opposite each other on the ends of the bench and the machinist vises on opposite sides.

For straightening pipe, rods, loosening threads of fittings, or doing other heavy pounding, an iron block, 1 by 6 by 18 in. should be placed near the edge along one side. To deaden the sound, a block of wood, about 1 in. thick, should be placed between the top of the bench and the iron block.

Norway, Mich. HENRY HOSKING.

AN INVESTIGATION to determine the distillation products of low-temperature carbonization of Utah coals at various temperatures and under different conditions will be undertaken by the Bureau of Mines, Department of Commerce, at its Pittsburgh experiment station. The following conditions will be studied: distillation in atmosphere of superheated steam; in atmosphere of preheated natural gas; in atmosphere of products of combustion of natural gas, and distillation by external heating retort.

QUESTIONS AND ANSWERS

Currents and Resistances in Closed Network

IF FIVE resistances are arranged as shown in Fig. 1 and an e.m.f. of 2 volts placed across the combination, is there any method by which the total resistance of the combination may be calculated and also the current in each section?

C. R.

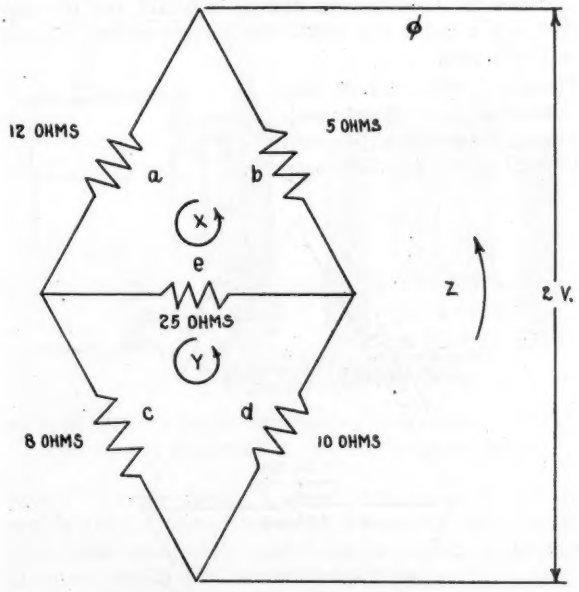


FIG. 1. FIVE UNKNOWN RESISTANCES ARE ARRANGED IN THE FORM OF A WHEATSTONE BRIDGE

A. Yes, there are several ways in which these values may be calculated, one of which is by the method of determinants, which is not nearly so formidable as it first appears.

In any network of conductors it is permissible for purposes of calculation to replace the actual currents through the network by imaginary currents flowing in the closed circuits formed by each mesh. These imaginary currents are taken as circulating in one direction, say a counter clockwise direction, and are all given the same sign, say positive. Should it be convenient for any other reason to take a current flowing in the opposite direction, it should be given a negative sign. In each mesh the sum of the IR drops equals the e.m.f. in the mesh, this being zero unless there is a generator. If the generator e.m.f. is in the same direction as the current, the e.m.f. is positive; if it opposes the imaginary current, the sign is negative.

In the foregoing example let a, b, c, d, e, and ϕ be the resistances of the branches. ϕ, not being given, is assumed to be zero. X, Y, and Z represent the imaginary currents in the various meshes as shown, the direction of each current being assumed to be clockwise. The only e.m.f. in the system is E produced by a battery in branch ϕ.

Then

$$X(a+e+b) - Y_e - Z_b = 0$$
$$Y(c+d+e) - X_e - Z_d = 0$$
$$Z(\phi+b+d) - X_b - Y_d = E$$

In order to make these equations all of the same form, rearrange them as follows:

$$-Z_b + X(a+e+b) - Y_e = 0$$
$$-Z_d - X_e + Y(c+d+e) = 0$$
$$Z(\phi+b+d) - X_b - Y_d = E$$

These equations may now be solved by the method of determinants as described below. Before taking up the actual solution, however, we shall review briefly the theory of determinants.

In order to solve such a series of equations, the following pair of "determinants" are written out.

$$Z = \frac{\begin{vmatrix} 0 & (a+e+b) & -e \\ 0 & -e & (c+d+e) \\ E & -b & -d \end{vmatrix}}{\begin{vmatrix} -b & (a+e+b) & -e \\ -d & -e & (c+d+e) \\ (\phi+b+d) & -b & -d \end{vmatrix}}$$

In this equation it should be noted that the denominator consists of the three terms of the three equations with the X, Y and Z terms omitted. The numerator differs from the denominator in that the column of Z terms is replaced by the terms on the right-hand side of the three equations. Were the X terms the unknown, the second column of the numerator would be replaced by the terms O, O, and E.

The numerator and denominator of the above equations each constitutes what is called a determinant and can be simplified by the following rules: When the value of Z has been found in this manner, the resistance of the circuit external to the generator is $\frac{E}{Z}$.

The following rules are to be observed:

(1) If a determinant has two equal rows or columns, it is equal to zero.

(2) To any row or column it is possible to add or subtract any number of times, any other row or column without altering the value of the determinant.

(3) To multiply any row or column by a number is equivalent to multiplying the whole determinant by that number.

(4) If all the terms in a row or column except one are zero, the determinant reduces to one of a lower order which may be obtained by striking out the row and column which intersect at the term in question, and multiplying the whole term by that term, the sign of the determinant being settled in the following way:

The line of terms beginning at the upper left-hand corner and ending at the lower right-hand corner is called the principal diagonal of the determinant. If the uncanceled term in the line of zeros is on the principal diagonal or is removed from it by an even number of terms, the term by which the determinant is multiplied in lowering its order is *positive*. If, however, this term is removed from the principal diagonal by an odd number of terms, the multiplying term is *negative*.

This is easily illustrated by an example, thus,

$$\begin{vmatrix} 1 & 5 & 6 & 3 \\ 2 & 1 & 1 & 5 \\ 4 & 3 & 2 & 1 \\ 0 & 2 & 0 & 0 \end{vmatrix} = 2 \begin{vmatrix} 1 & 6 & 3 \\ 2 & 1 & 5 \\ 4 & 2 & 1 \end{vmatrix}$$

$$\begin{vmatrix} 1 & 5 & 6 & 3 \\ 2 & 1 & 1 & 5 \\ 4 & 3 & 2 & 1 \\ 0 & 0 & 2 & 0 \end{vmatrix} = -2 \begin{vmatrix} 1 & 5 & 3 \\ 2 & 1 & 5 \\ 4 & 3 & 1 \end{vmatrix}$$

It is immaterial whether the distance from the diagonal is counted along a row or a column.

(5) A determinant of the second order is expanded in the following manner:

$$\begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix} = a_1 \ b_2 - a_2 \ b_1$$

The reduction is effected by alternating the terms in accordance with the foregoing rules until a row on column is obtained in which all terms but one are zero. This enables a reduction or order to be effected in accordance with rule 4.

Now we can proceed to substitute the value of the given equation in our pair of determinants.

$$Z = \frac{\begin{vmatrix} 0 & 42 & 25 \\ 0 & -25 & 43 \\ 2 & -5 & -10 \end{vmatrix} = 2 \begin{vmatrix} 42 & -25 \\ -25 & 43 \end{vmatrix}}{\begin{vmatrix} -5 & 42 & 25 \\ -10 & -25 & 43 \\ 15 & -5 & -10 \end{vmatrix}}$$

In the denominator,

subtract + 5 times col. 1 from the last col.
subtract — 8.4 times col. 1 from col. 2

$$= \begin{vmatrix} -5 & 0 & 0 \\ -10 & -109 & 93 \\ 15 & 121 & -85 \end{vmatrix} = -5 \begin{vmatrix} -109 & 93 \\ 121 & -85 \end{vmatrix}$$

The numerator then is:

$$2 \begin{vmatrix} 42 & -25 \\ -25 & 43 \end{vmatrix} = 2 \left[(42 \times 43) \right] - \left[(-25) \times (-25) \right]$$

$$= 2 \ (1806 - 625) = 2362$$

and the denominator is:

$$-5 \begin{vmatrix} -109 & 93 \\ 121 & -85 \end{vmatrix} = -5 \left[(-109) \times (-85) \right] - (121 \times 93)$$

$$= -5 \ (9265 - 11253) = 9940$$

$$Z = \frac{2362}{9940} = 0.2376 \text{ amp.} \quad R = \frac{E}{Z} = \frac{2}{0.2376} = 8.41$$

ohms.

In Fig. 1 assuming bridge e to be removed, the resistances a + c, and b + d are:

12 + 8 = 20 ohms and 5 + 10 = 15 ohms

E = 2 volts.

$$I = \frac{E}{R} = \frac{2}{20} = 0.1 \text{ amp. which is the current in a c}$$

$$I = \frac{E}{R} = \frac{2}{15} = 0.1333 \text{ amp. which is the current in b d}$$

0.2333 amp. total current in two branches.

Since the total current flowing is 0.2376 and the current in a c and b d is 0.2333 the current in the bridge e is 0.0043 amp.

Current in a c = 0.1000 amp.
Current in e = 0.0043 amp.
Current in a = 0.1043 amp.
Current in b = 0.1333 amp.

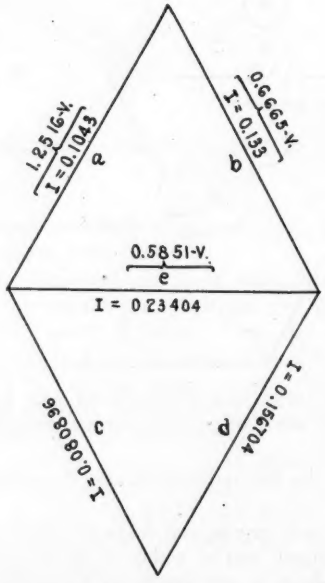


FIG. 2. CIRCUIT DIAGRAM SHOWING VALUES OF CURRENT IN EACH BRANCH

Voltage across a = E = R I = 0.1043 × 12 = 1.2516
Voltage across b = E = R I = 0.1333 × 5 = 0.6665
Difference in potential between M and N = 1.2516 — 0.6665 = 0.5851 volt across e.

$$\text{Current through e} = I = \frac{E}{R} = \frac{.5851}{25} = 0.023404 \text{ amp.}$$

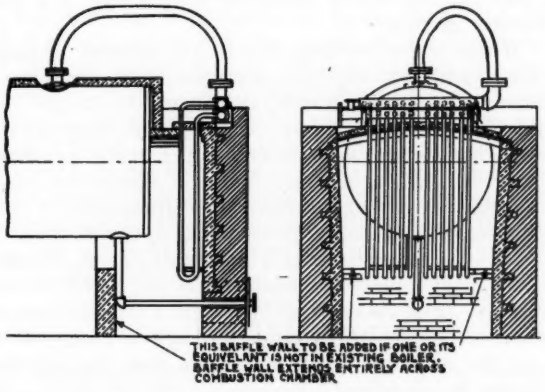
Current in c = a — e = 0.104300 — 0.023404 = 0.080896 amp.
Current in d = b + e = 0.133300 + 0.023404 = 0.156704 amp.
Proof: d + c = 0.080896 + 0.156704 = 0.2376 amp., total current.

Superheater for H. R. T. Boiler

PLEASE show an acceptable method of installing a superheater in horizontal return tubular boiler setting. I am of the opinion that the space between the boiler and the rear wall could be used but with a 150-hp. boiler, such as we have here, will a distance of 20 in. between the boiler and rear wall be sufficient to permit a superheater installation and still cause no restriction of gas flow?

W. J. M.

A. As you have assumed, the standard method of installing a superheater in a horizontal return tubular boiler setting, is to place the tubes between the boiler and rear wall as shown, in the accompanying figure. The question as to whether the space of 20 in. between the rear wall and the boiler is wide enough cannot be answered directly for we do not know the exact space occupied by the superheater. It would appear, however, if the boiler is approximately 150 hp. and of the usual dimensions, that a somewhat wider space at the rear would be needed. A distance of approximately 4 ft. would be much better.


THIS BAFFLE WALL TO BE ADDED IF ONE OR ITS EQUIVELANT IS NOT IN EXISTING BOILER. BAFFLE WALL EXTENDS ENTIRELY ACROSS COMBUSTION CHAMBER

THIS IS THE STANDARD METHOD OF INSTALLING A SUPERHEATER FOR HORIZONTAL RETURN TUBULAR BOILER

Electrolytic Corrosion in Boilers

PLEASE furnish information as to the amount of electric current, particularly the voltage that will produce electrolytic corrosion in steam boilers. G. H. E.

A. According to the theory of electro chemical corrosion, boiler surfaces are attacked in the presence of injurious constituents in the water of the feed system, such as acids, grease, or oxygen. Galvanic action is set up by irregularities of composition of material due to lack of homogeneity in the metal structure of the tubes or tube walls. This difference of potential at various portions of the boiler causes those portions which are more anodic than the adjacent to become the wasting or corroding poles of numerous little couples or batteries and are eaten away or corroded.

The difference of potential set up between any two poles, either in the boiler shell itself or between the shell and zinc plates in the boiler, is a function of the materials involved. For iron or steel, it would be one value; for copper, another. In boiler corrosion the voltages produced are dependent largely upon the nature of the impurities in the metal. In any case, however, they are extremely small, usually in the order of 0.1 or 0.2 v.

The process of chemical corrosion is accumulative; in other words, an extremely small current flowing over an extended period of time will produce the same results as a large current flowing for a short time. The question of voltage enters in only as a means of forcing currents of certain values to flow. It is the quantity of electricity involved, or, as it is commonly expressed, the current in amperes that is the important factor.

In order to overcome such corrosion, it has been the practice for many years to fit boilers and condensers with zinc and steel slab protectors without applying any external electromotive force. By this method galvanic action of only moderate strength is produced, as steel and zinc are more anodic in comparison with the metal of the boiler. Such zinc or steel plates are effective in counteracting corrosion when they are new but as the zinc is used up and becomes coated with scale or oxides, the action diminishes considerably and, in order that the boilers may be further protected, they must be renewed.

In a new system of boiler protection recently developed a small e.m.f. is supplied from an outside source, such as a battery or small motor generator set. This potential is impressed on suitably placed electrodes immersed in the boiler water which thus acts as the electrolyte. When a sufficiently strong electric current is so supplied the corrosive effect on the boiler surfaces will be eliminated. In a particular case with an apparatus of this type, a potential of 6 v. was sufficient to neutralize the electrolytic action in the boiler and with 6.4 v. and a current of 9.6 amp. the boiler was maintained sufficiently negative to prevent all corrosion.

Judging by the low voltages used in preventing corrosion by this method, it is apparent that the voltages generated by the natural battery action in an ordinary boiler must be somewhat of the same order. As a matter of fact, as stated above, they are usually even lower.

Boiler Plates Bowed Up by Oil on Tubes

WE HAVE for consideration a horizontal return tubular boiler 84 in. in diameter and 20 ft. long. The shell plates are $\frac{9}{16}$ in. thick, with three through rods below the tubes and six through rods above the tubes. The boiler contains 118 4-in. tubes and is supported at four points as recommended by the A.S.M.E. Code, and built in three courses.

When this boiler was recently inspected the bottom of the shell inside of the boiler was found clean, but the tubes and the through stayrods above the tubes were covered with a coating of oil about 1/64 in. thick, as well as the front head above the tubes.

Below the tubes the through stayrods were loose, the bottom tubes were bent up against each other and some of the beads were cracked at the rear head, the tubes in this case being hot finished seamless steel. The bottom of the boiler was bowed up and when a line was stretched under the boiler, it was found that the center course at the center of the boiler was up $1\frac{1}{8}$ in. The tubes showed a tendency to push out through tube holes, but most of them held and buckled.

In this case is it possible with the bottom plates of the boiler kept clean so the heat could be conducted away by the water, that the tubes became overheated on account of the oil and when they buckled, they pulled in the heads? When the excessive strain was put on the bottom sheets, although at normal temperature, would not the metal tend to pull away from the fire?

This boiler was being fired with bagasse and was carrying 125 lb. pressure.

If any reader has a different reason for the sheets being forced up, I shall be pleased to know the details.

W. E. S.

EDITORIAL COMMENT

Differences Count, in Men and Power Plants

To the engineer who has been following closely the progress of central station design—and what engineer has not—the description of the new Twin Branch station in this issue should prove of particular interest. For this plant is an unusual combination of standardization and daring innovation and, to the best of our knowledge, there is nothing else quite like it in the country. In the first place, on viewing Twin Branch from a little distance for the first time, most engineers will exclaim, "Why, it looks just like Philo!" Well, it was constructed from the same building plans, and the arrangement of principal equipment inside the plant is practically the same.

In the minds of many engineers this may give rise to the question, "Is it possible that we shall ever be able to standardize large central stations?" In our opinion, no. Look over the arrangements and designs of a dozen central stations built during the past year and you will see very little standardization. What we are getting is a style, rather than a standardization, of central station design, in which certain fundamentals are agreed on, but in which the application of these fundamentals must vary. In short, the differences between Philo and Twin Branch, rather than the similarities, will determine their performance, just as they do in the case of two human beings, which is a perfect illustration of what we mean by style rather than standardization.

Closer examination of details shows many such interesting differences. Where vertical surface condensers were used at Philo, single-pass horizontal condensers were employed at Twin Branch, advantage being taken of the head of water at the adjacent hydro plant to secure gravity flow of circulating water and to eliminate circulating pumps entirely. Although these pumps are installed at Philo, they are not used more than three months a year, but at Twin Branch they are not even installed in the station. The saving in fixed and operating charges that can be made in this way is really important and will undoubtedly have its effect on the heat economy. The use of the adjacent small hydro-electric plant as a house generator is decidedly original.

To a certain extent, then, standardization of a sort may be possible, as far as it concerns the larger and fundamental equipment of stations, such as turbines, boilers, feed pumps, and some of the other auxiliaries. A careful comparison of the details of Twin Branch with those of Philo will show, however, the necessity for adapting these more or less standard designs to the particular conditions encountered. That very necessity makes for progress and points the way to higher economies in coal burning. Philo started the central station field with its high economy and it is reasonable to expect that Twin Branch will be able at least to equal Philo's performance. If Twin Branch makes a better record, it will be because of the differences between the two instead of the resemblances.

The Automaton Enters the Power Plant

Those of us who, thirty years ago, marveled at the intricate mechanism of the Columbus clock which automatically staged a complete show with dolls, bells, whistles and other paraphernalia designed to give a realistic performance may now step into power plants and witness not a play but real useful machinery functioning in a most exacting manner.

Where several million dollars are invested in power plant machinery, engineers have found it advisable to eliminate, as far as possible, all dangers due to the inaccuracies of workmen by so designing and equipping the plant that its routine operation is practically automatic. Only when shifting the load from one piece of equipment to another is it found necessary for attendants to direct operations in the leading power plants of the country. No longer is it necessary to have men stationed at numerous places about a plant to operate valves and throw switches at signals from the engineer in charge. Centralized control places all coordinated work of this sort in charge of one man who is guided by instruments to show the conditions affected by his actions.

Centralized control had its advent with remote-controlled switching equipment some 20 yr. ago; then came electrically-operated valves and control of turbine speed from the switchboard, which, with feed water regulators, pump governors, draft regulators and numerous other automatic devices and highly developed instruments, have placed the power plant as much in control of one man as is a pipe organ in the hands of a master artist. The extent to which centralized control has been reached at Cahokia Power Station is detailed in the article by Mr. Lange in this issue which is an indication of present achievement along this line.

We Are Moving Forward

In many cases the coming of the new year is marked by inventories of equipment and supplies. At such a time, when the owner's attention is focused on this equipment, the power plant engineer should seize the opportunity to call attention to the defects and inefficiency of obsolete apparatus while making a plea for more modern devices. Much has been done to improve power plant efficiency, yet there is room for a world of improvement.

Beginning, as we are, the second quarter of the 20th century with a greater and broader knowledge of fundamentals, we should attack our problems with even greater vigor than did those who were at the throttle when this century was ushered in. There have been so many astonishing inventions and developments in the past 25 yr. that today we are in a more receptive mood for changes than formerly.

In almost all industries and lines of endeavor, apparatus once considered the finest and best of its kind is constantly being replaced by more efficient designs. In

the power plant, in a majority of cases, the reciprocating steam engine has given way to the turbine and in many places, where heating is not a consideration, even the turbine has bowed to the Diesel engine.

Electricity now furnishes increased flexibility of control for individual machines where once cumbersome line shafts and belting had to be endured. Railroads with their inefficient steam locomotives are beginning to electrify their lines, or, in some cases, use Diesel engines.

Except in a few of the older, less progressive plants, stokers have replaced hand firing and now new developments in pulverized fuel burning seem to point the way to further improvements in combustion methods.

Low-temperature carbonization, in which recently there has been awakened interest, gives promise of great conservation of our coal supply.

In the best boiler practice for the larger plants, the fire tube has long since succumbed to the water tube and now it is believed the orthodox design of this latter type will undergo radical changes. Already water-cooled furnace walls have come into prominence and the day is not far distant when boiler designers will simplify three- and four-pass boilers. Over 75 per cent of the heat absorption takes place in the first pass so that it seems a needless waste of space to have two or three more passes to absorb the remaining 25 per cent of heat. Water-cooled furnace walls and sufficient economizer surface, may, it would seem, be substituted.

Off Duty

It is customary at this time of the year or thereabouts to take stock of our accomplishments and to prove, whether we have really done anything or not, how much better the world is for our being here. The manufacturer of radio receivers, for instance, shows by an alinement chart that if all the howls let out by his receivers during the year were combined into one, the resultant screech would shock the moon out of its orbit. The maker of cosmetics proudly boasts that if the year's output of lipsticks were placed end to end around the equator and left there, all the movie queens in Hollywood would die of pernicious anemia within a month. The prohibition agents prove that the country is dry and show that it will be drier next year and the bootlegger points with pride to the size of the rum fleet. Summing up all these illuminating reviews and predictions, averaging them, and allowing for a suitable factor of ignorance, we come to the astonishing conclusion that the world is perfect and that everybody's happy. How interesting!

Twenty-three hundred years ago, a little more perhaps, a notorious soap box orator of Athens was jerked from his perch at the corner of Main and Market Streets, and hauled into court to answer charges that he was demoralizing and corrupting the mind of youthful Greece; at least so the newspaper headlines put it. As a matter of fact, he was doing nothing of the sort since he was only telling the Athenian youths to think for themselves instead of swallowing the stories the old fogies of the day insisted that they do. Hauled before the Dept. of Justice, these patriarchs thought that they would make him recant and behave himself. But the old fellow was not to be railroaded in any such manner; he had a mind of his own and calmly told them to go walk around the square, or words to that effect. True, this attitude cost him his head but the speech that Socrates made before the judges who were to decide his fate was one of the most delightful bits of common sense ever addressed to any audience and to this day remains the basis of all pleas for tolerance. "No person on earth," said Socrates, "has the right to tell another man what he should believe or deprive him of the right to think as he pleases." There was more to it, of course, but this is the central idea around which the whole speech revolves.

Clear, isn't it? Axiomatic in its simplicity, yet the idea has made little headway. As I stated before, at this time of the year, the world proudly recounts its progress along mechanical lines and boasts of its scientific achievements and here it has done wonders, but when it comes to plotting progress in the development of common sense, the curve is uncomfortably flat. Socrates' plea for tolerance has gained only little support. The meaning of the word is scarcely understood.

In Baltimore lives a man of brilliant intellect whose biting criticism of life and whose eloquent, though blistering, plea for truth and freedom has scorched every sham and prudery in the nation. His unrelenting denunciation of those whose ignorance and hypocrisy tend to suppress every vestige of freedom and human right has brought forth from his enemies a storm of indignation and protest. But without avail, the crystalline truth of his criticism stands, it repels all counter attack and, today, he is more feared by his enemies whose shams he has shattered, than ever before. The very mention of his name in certain circles bestirs the truculent instincts of the hearers.

In approaching an acquaintance several days ago, I had under my arm a book written by this famous Baltimorean. "Do you like that stuff?" was my acquaintance's first remark, referring to the book.

"Certainly," said I, "why not?"

"Well," he said, and here his countenance assumed a look of compassion, for me I suppose, "Mencken is entirely too harsh, too intolerant. Don't you think that much more can be accomplished by a spirit of tolerance?"

And there you have it. The average person yelling for tolerance doesn't know the meaning of the word. This very acquaintance, who tried to preach tolerance to me, would be the first to put his name on a petition to suppress Mencken's criticism. His tolerance, like that of many others, extends only to those who think as he does. Any other kind of thinking is vigorously combated.

Let us examine Mencken's own ideas on the subject. "No conceivable moral purpose," says he, "is higher than the right of the citizen to think whatever he pleases to think and to carry on his private life without interference by others."

Is that intolerance? It sounds strangely like the plea of wise old Socrates before the Athenian tribunal over two thousand years ago. And, stranger still, this modern plea is regarded in much the same manner as was the Athenian philosopher's. There are those who, today, would gladly hand the cup of Hemlock to the Maryland Socrates.

No, we may have made strides in science, in improving the health and comfort of the masses, in building skyscrapers and in methods of wholesale destruction during war, but to recount in writing progress in the development of a spirit of tolerance during the past twenty centuries, we would need only a small sheet of paper.

Yearly Index

INDEX for Volume XXIX of Power Plant Engineering is now prepared and will be sent free to subscribers upon request.

Midwestern Engineering and Power Exposition

WILL BE DEMONSTRATION OF THE LATEST DEVELOPMENTS IN POWER PLANT ENGINEERING AND EQUIPMENT. FOUR DAY CONFERENCE ON POWER RESOURCES AND BEST METHODS OF UTILIZING FOR THE BENEFIT OF THE PEOPLE

DURING the week of Jan. 25 to 30 will assemble in Chicago a notable gathering of engineers and power plant executives to visit the Exposition of power and engineering equipment at the American Exposition Palace and to attend the Midwest Power Conference in the rooms of the Furniture Club—both at 666 Lake Shore Drive.

The building, known as the Furniture Mart, is easily reached by the Chicago Avenue street cars which pass the main entrance or by the Grand Avenue line, two blocks south. Michigan Avenue motor buses operate from the loop and run four blocks west of the building and the Yellow Cab and DeLuxe services have large stations adjoining the Mart. The main entrance to the Exposition will be on Lake Shore Drive and that for the Conference on Erie St. with ample elevator service to the Furniture Club.

In the exposition hall will be found exhibits of more than 175 manufacturers of power apparatus, many showing actual operation of their product, others detail parts and installation under plant conditions. Moving picture films will show the processes of manufacture and operation of many of the products and those in charge of exhibits will be competent and interested to explain and answer inquiries. The exposition will offer the finest kind of an opportunity for investigating equipment and studying its operation as well as what it will accomplish when installed in any given plant.

FURNITURE MART, 666 LAKE SHORE DRIVE, CHICAGO, WHERE CONFERENCE AND EXHIBITION WILL BE HELD.

CONFERENCE SESSIONS

These will be held Tuesday afternoon to Friday morning. The Conference has been arranged by a committee appointed by the local and regional organizations of the American Institute of Electrical Engineers, American Institute of Mining Engineers, American Society of Mechanical Engineers, National Electric Light Association and National Safety Council. Papers will be presented on the power resources of the country, more especially of the middle west, and on how best to develop and utilize these resources for the benefit of the communities and the people. The speakers will be foremost authorities on their respective subjects and will bring messages worthy of the most careful attention. Time will be afforded and arrangements made for inspection trips to various plants including the Crawford Ave. Plant, Underwriters Laboratories, Western Electric Plant, International Harvester Co. and the new Tribune Plant. This power week in Chicago will be of vital interest and importance to all men engaged in power plant engineering or any of its related branches.

Entertainment is arranged for ladies who attend and will include affairs of special interest and attraction. This part of the program is in charge of Miss May Fletemeyer, which insures its success.

The Conference will open Tuesday afternoon with an address by Samuel Insull on Power Developments in the Mississippi Valley. Wednesday morning will be devoted to hydraulic power and inter-connection of systems with papers by Daniel W. Mead of Madison, Wis., on Hydraulic Power in the Middle West, by H. Birchard Taylor of Philadelphia on Changing Viewpoints in Hydraulic Practice, by L. F. Harza of Chicago on Suggestions Regarding Hydraulic Plant Operation and by R. F. Schuchardt of Chicago on Superpower in the North Central States.

Wednesday afternoon will be given to steam station practice with papers by William S. Monroe of Chicago on Electric Power in the Chicago District, by C. F. Hirshfeld of Detroit on Pulverized Fuel in Steam Making, by H. W. Brooks of Fullerton, Pa., on By-Product Processing of Coal and by Dr. R. E. Hall of Pittsburgh on Boiler Water Conditioning, Especially for High Operating Pressure.

The Thursday morning session will take up industrial plants and distribution with papers by Paul L. Battey of Chicago on Layout and Operation of Industrial Power Plants, by G. B. Warren and J. H. Keenan of Schenectady, N. Y., on Testing Steam Turbine Nozzles by the Reaction Method, by G. C. Neff of Madison, Wis., on Rural Electric Service and by J. Paul Clayton of Springfield, Ill., on Purchased Power for Coal Mines. An address will also be given on Safety and First Aid in Industrial Plants with a demonstration of rendering first aid by a trained team.

Inspection trips will occupy the afternoon.

Thursday evening a dinner meeting will be held with Charles Piez of Chicago as toastmaster. Speakers of note will present the effect of wide development and availability

of power on the economics of our social and industrial life, and General Charles Keller, Supervisor of Power during the war, will explain the place of power in our plans on national preparedness.

Friday morning, the place of oil and gas in our power system will be considered, with papers by Max Rotter of St. Louis on the Diesel Engine in the Industries, by Samuel M. Vauclain of Philadelphia on The Diesel-Electric Locomotive, by Allen H. Brewer of New York on Economics of Oil as a Boiler Fuel and by H. H. Clark of Chicago on Gas in the Industries.

For the afternoon, inspection trips will be arranged to suit the wishes of visitors.

In the Exhibit Hall

Aero Pulverizer Co., 165 Broadway, New York, will be in booths 402-3 with a display of its pulverizer system showing the special manganese steel construction of the parts, the roller bearings and action of the heavy paddles and side-dump trash separator.

Air Preheater Corp'n., 25 Broadway, New York, will have in booths 214-16 an exhibit of the Ljungstrom air preheater, the Howden air compressors, apparatus for forced draft systems and a demonstration of its patented furnace fronts.

Alberger Heater Co. of America, 281 Chicago St., Buffalo, N. Y., will occupy booth 220 with a display of the Howard guided expansion joint and Alberger-Buffalo heaters, with helically corrugated copper tubes and divided floating tube head, also heat exchangers of similar construction.

Alexander Brothers, 14 South St., Philadelphia, Pa., will show, in booth 107, its Tentacular suction belt consisting of a backing of oak tanned leather or balata belting having attached to the under side narrow longitudinal strips of special soft chrome-tanned leather, held in position by hollow brass rivets, clinched well in so as to leave pockets at the bottom of the strips. A running drive with 3½ and 26-in. pulleys on 24-in. centers will demonstrate the effectiveness of the belt, and the steadiness of the drive.

The Allen-Sherman-Hoff Co., 261 So. 15th St., Philadelphia, Pa., will display, in operation, a complete A-S-H Hydrojet system for handling ashes. This will illustrate the action of a storage tank discharging into a sluice which will carry them to a sump, whence they will be pumped to the tank as to an ash car. Details of the system such as ash gates, pumps, sluice and pump lines, ash storage tanks and hoppers will be illustrated. Of special interest will be the cast-iron bunker construction and tile-lined ash hoppers and intermittent action of high-velocity water streams in horizontal sluiceways. The display will be in booth 446.

Allis-Chalmers Co., Milwaukee, Wisc., will display its line of steam and hydraulic turbines, steam engines, electrical machinery, pumps, air compressors, transmission equipment and special industrial machinery for mining, flour mills, saw mills and cement plants in booth 256.

American Arch Co., 17 E. 42nd St., New York, will display its suspended arches with cross pieces carrying pressed steel clips for supporting the interlocking filler tile. Any section is easily renewable as will be demonstrated in booths 358-59.

American Asphalt Paint Co., 844 Rush St., Chicago, will have its exhibit in booth 39. An interesting moving picture will show the difficulties under which Gilsonite asphalt is mined and the various steps in the manufacture of Valdura asphalt paint. The story will be told and pictures explained by practical paint experts who will be glad to answer all questions.

American District Steam Co., No. Tonawanda, N. Y., will feature its Adsco line of expansion joints, especially its duplex-sleeve guided type for high-pressure and superheated steam service, having an inner and outer slip welded together at one end with the outside surface of the outer slip riding against the packing. Space between the outer and inner slips is cooled by air circulation. The joint has either cast-iron or steel body furnished with flange or bevel ends, as is also the slip, so that it can be used in flanged work or welded into the pipe line. Other Adsco devices exhibited will be packless diaphram, standard pressure guided and standard pressure anchor and service expansion joints, St. John steam flow and Simplex and Adsco rotary condensation meters, reducing valves and angle fittings. A full size cross section of 12-in. underground steam line and 6-in. return will show actual construction for high-pressure service. Booth 115 will house the exhibit.

American Electric Motors, Inc., 57 Erie St., Milwaukee, Wisc., will exhibit, in booth 222, its line of special motors, starting boxes and automatic control devices.

American Pulverizer Co., 18th and Austin Sts., St. Louis, Mo., will have its exhibit in booth 446. It will demonstrate its process for reducing run-of-mine coal to sizes for stokers or for pulverizing machinery by means of its American ring coal crushers.

American Steam Pump Co., Battle Creek, Mich., will have its line of American-Marsh pumps in booths 319-20. This will include simplex, duplex and centrifugal forms for boiler feed, wet and dry vacuum, condensation, bilge and hydraulic pressure. Also air compressors and jet condensers.

Andale Engineering Co., 522 Walnut St., Philadelphia, Pa., will display its duplex oil and water strainers and show their construction by sectioned and disassembled models in booths 211-12. Also coolers for lubricating and transformer oil, heat exchangers and inter and after coolers.

Andrews-Bradshaw Co., 531 4th Ave., Pittsburgh, Pa., will have a complete, full-size working model of the Tracifier in operation in booths 273-74. It will show the complete removal of fog, mist and other forms of boiler water from steam and its action as a steam-purifier.

Armstrong Machine Works, Three Rivers, Mich., will exhibit the various sizes of steam traps which it manufactures, with sectioned models showing the interior construction and mechanism. There will also be a glass model of the No. 2 trap in operation under steam pressure, draining a radiator to show the complete operation and how fully the trap drains away condensate. It will show the elimination of air binding, absence of steam leakage, quick opening and closing of valves and the self-scrubbing action of the Armstrong trap. The exhibit will be in booth 337.

Atwood & Morrill Co., Salem, Mass., will display in booth 446 its line of heavy duty valves for high-temperatures and pressures and demonstrate the special points of design and construction. Also special valves of low-pressure bleeder heating and a new damper regulator.

Automatic Primer Co., 111 W. Washington St., Chicago, will display in booth 57 its Apco primers for centrifugal pumps. This device permits the use of a horizontal pump on suction lifts without foot valves or mechanical contrivances for producing vacuum.

Bailey Meter Co., E. 46th St. and Euclid Ave., Cleveland, O., will have its display in booths 5-6-7-8. The company expects to have a number of new developments on exhibit, including the Bailey meter control equipment for automatic boiler operation. This will be running to demonstrate its action and the method of control. There will also be a section of the new Bailey furnace wall shown, designed to reduce maintenance costs and permit of operating at higher ratings. Operation of the new Bailey pulverized coal feeder and meter designed to give a uniform rate of coal feed from bin to burner will be demonstrated by a full size feeder with maximum capacity of 10,000 lb. of coal an hour. Standard types of Bailey boiler meters will also be displayed.

Barco Manufacturing Co., 1801 Winnemac Ave., Chicago, will be in booth 29. It will exhibit its lubricated plug valves, flexible joints and Argyle-Titan electric drills. The valve is balanced by pressure of a spring ring so that it is non-sticking and has lubricant forced to wearing surfaces under pressure. The flexible joints have a ball, turning in a double gasket which gives two seats. It is with screwed or flanged ends, for ¼ up to 36 in. and in straightway, 45-deg., 90-deg., or 180-deg. forms.

Barratt-Christie Co., 37 So. Clinton St., Chicago, will have Armstrong steam traps, Lumen Machinebronze and the Wood Shovel & Tool Co.'s Molybdenum shovels and scoops in its exhibit in booth 338. The Instant water heater will be included and the Durabla sheet and rod packings and high-pressure gage glasses.

Bartlett-Hayward Co., Baltimore, Md., will be in booths 211-12, where it will display the Fast flexible shaft couplings, made entirely of metal with double engagement and positive lubrication by a permanent film of oil. Special forms for steel mill service will be shown and photographs of representative installations.

The Bayer Co., 4067 Park Ave., St. Louis, Mo., will exhibit its usual line of mechanical soot blowers in booths 447-8. These will be for tubular and water-tube boilers, illustrating details of construction, arrangement of equipment and methods of control.

R. H. Beaumont Co., 319 Arch St., Philadelphia, will have booth 341. Here will be found a model centralized coal handling system for a boiler house, including working models of the Beaumont Skip hoist, coal-weighing larry and cable drag scraper. Coal will be elevated from the track hopper to overhead bunker by a skip hoist operated by a full size winding machine. From the bunker, a larry will demonstrate weighing coal and distribution to the stokers. A model cable drag scraper will illustrate the storing and reclaiming of coal from a miniature storage field, all details being complete. The Beaumont Manufacturing Co. will show a section of copper steel ash hopper with full size pivoted ash gate for discharge to small cars and larries. Water quench-

ing of ashes in the hopper will illustrate the thorough draining by the ash-gate drains. A full size power-operated ash gate will show the equipment furnished for discharging to railroad cars or trucks.

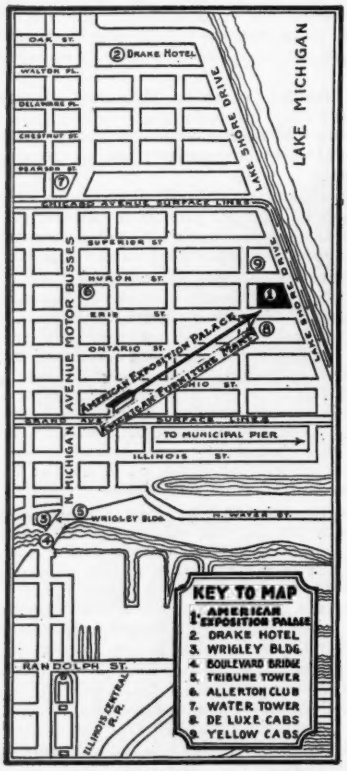
BETHLEHEM SHIPBUILDING CORP'N, Ltd., Bethlehem, Pa., will show, in booth 102-3, its Bethlehem-Weir direct-acting feed pump, turbine-driven pumps, open and surface feed heaters, condensers, Dahl oil burning system, oil engines, evaporators, air compressor and deaeration system.

BETHLEHEM STEEL CO., INC., Bethlehem, Pa. This exhibit will be in booths 110-11, showing a full sized Bethlehem pulverizer plant of roll tire type, designed for pulverizing fuels or any other mineral or granular matter.

BOSTON GEAR WORKS SALES CO., Norfolk Downs, Mass., will be found in booth 418, with an exhibit of standardized speed-reduction units, Boston silent-chain drives and hardened and ground gears.

BOTFIELD REFRACTORIES CO., Swanson and Clymer Sts., Philadelphia, Pa., will show a number of forms of unusual fire-brick construction, among them an air-set arch. Its Adamant high-temperature fire brick cement for furnace construction and repair will be demonstrated and illustrations shown of how it is used, in booth 17.

BOYLSTON STEAM SPECIALTY CO., 116 W. Illinois St., Chicago, will display, in booth 421, its line of steam plant devices. The



LOCATION OF AMERICAN FURNITURE MART

Boylston improved steam trap will be shown in detail, also the pressure regulating valve, demonstrated by a sectioned model. Back-pressure valves for universal applicaton, tank valves, temperature controllers, strainers, will be on display. Features are the adjustable stop, interchangeability of parts, simplicity. Water sprays and pump governors will form a part of the exhibit.

THE BRISTOL CO., Waterbury, Conn., will display, in Booth 104, its line of recording pressure gages, draft gages, thermometers, pyrometers and the like, with the new Bristol-Derr water level gage for steam boilers as a special feature. This operates on the thermo-electric principle, permitting the recording or indicating instrument to be located at any convenient point at a distance from the boiler.

THE BROWN INSTRUMENT CO., Philadelphia, Pa., will exhibit a complete line of indicating, recording and control instruments for power plant service. An outstanding feature will be the Brown electric CO_2 meters combined with flue gas temperature pyrometers, both indicating and recording types in actual operation. An illuminated 12-in. dial will indicate CO_2 from 0 to 24 per cent by 1 per cent divisions. Lead-lined cells, batteries automatically charged and cells balanced in the recorder will be some of the details demonstrated. Automatic damper control for draft regulation in connection with the above instruments will be another feature. Brown recording pyrometers, of single, duplex and multiple models will be shown in a new design with glass tear-off strip and completely visible record. Indicating and portable pyrometers, thermo-couples, standard long distance one, two and three pen recording and indicating thermometers, electric tachometers for showing stoker and turbine speeds, a new liquid-level recorder and gages for vacuum, draft and pressure will be included in the display in booth 128.

BRUNSWICK-KROESCHELL CO., 4221 Diversey Ave., Chicago, will show, by large photographs, its plants and the interiors of its factories for making boilers and refrigerating machinery, also the details of construction of these machines. Probably an ice machine will be displayed and parts of boilers to show design and construction. The exhibit will occupy booth 30.

BUILDERS IRON FOUNDRY, Providence, R. I., will display its Venturi meters in booth 62. In the exhibit will be included the type M register-recorder and indicator in actual operation measuring the water pumped through a small Venturi tube. Other features will be the type GK indicator-recorder, cast-steel Venturi tube for high pressure, barometric manometer, Venturi nozzle for steam and a small Venturi tube and oil seals used in connection with the type M register-indicator-recorder for the measurement of liquid ammonia.

BUFFALO FORGE CO., 490 Broadway, Buffalo, N. Y., will have on display its boiler feed pumps, cooling fans and a special fan designed for use in power plants. This is the Duplex Conoidal induced draft fan with straight blades and the water-cooled bearings outside the structure, away from the hot gases. Also will be shown the Breezo-Fin unit heater and the Carrier air-washing system for heating and ventilating systems. The exhibit will be in booths 50-51.

BURKE ENGINEERING CO., Holland, Mich., will make a comprehensive exhibit, in booths 347-48, of its traveling grate stoker, its fuel-saving, smoke preventative furnace and the U. S. rocking grate, showing the details of construction and method of action of each piece of equipment.

CARR FASTENER CO., 31 Ames St., Cambridge, Mass., will feature its Dot system of high-pressure lubrication in booth 18. Special nipples, with or without grease cups, are applied at points where lubrication is needed and grease or oil is forced in under 3000-lb. pressure. For small systems, a hand compression gun is used, and for larger systems a compressor and tank, operated by either hand or power, according to size. The power compressor will be a particular feature of the exhibit.

CARRICK ENGINEERING CO., 538 S. Clark St., Chicago, will have a display of its furnace regulators, chronometer valves and mercury-actuated master control, demonstrated by working models in glass inclosures to show the regulation secured by this system. The exhibit will be in booth 261.

THE CASEY-HEDGES CO., Chattanooga, Tenn., will exhibit in booth 431 parts of its C-H water tube boilers and illustrations of the different types including the longitudinal and cross drums with either horizontal, vertical or combination baffles.

A. W. CASH CO., Decatur, Ill., will have an exhibit in booth 251 of its complete Craig system of combustion control, including the type S master controller. This controller, actuated by steam pressure, regulates the forced-draft fans, stoker engines and boiler uptake dampers. Automatic regulators of furnace-pressure type are applied to the blast dampers at each wind box. There will also be shown the company's complete line of automatic pressure regulating devices for use in steam, air, gas, condensing and refrigerating systems.

CENTRIFIX CORP'N, 3029 Prospect Ave., Cleveland, Ohio, will occupy booth 19 with a display and demonstration of its system for purifying steam.

CHAPMAN VALVE CO., Indian Orchard, Mass., will display its line of valves in booth 348. It will feature specially fittings and valves of chrome nickel steel designed for high-pressure and temperature conditions, also its remote control system with signal lights; red to indicate open, green, closed, and white the mechanism in operation.

CHICAGO CHEMICAL CO., 6216 W. 66th Pl., Chicago, will have an exhibit of its K. W. S. Sodium Aluminate in booth 60 and will demonstrate the business of this product in hastening precipitation in lime and soda-ash softening plants. The representatives will also explain the company's method of treating boiler feed water internally.

CLARAGE FAN CO., Kalamazoo, Mich., will exhibit its FD high-speed blower for forced draft in booth 262. This has two single inlet wheels equipped with grease-type, SKF ball bearings having independent supports outside the housing. This housing is of split type, rigidly stiffened with angles and channels, and removable

in sections. Another feature will be a 4 by 4 in. vertical steam engine designed for fan or stoker drive.

CLEVELAND WORM & GEAR CO., 1667 E. 40th St., Cleveland, O., will be in booths 211-12 with a display of motor-driven worm gear speed-reducing units.

COKAL STOKER CORP'N, 411 E. Ohio St., Chicago, will be found in booth 340 with a demonstration of its power feed stoker which is driven by a ¼-hp. motor attached to a lamp socket. This will show the overhung arch, coal hopper, feeding mechanism for power or hand operation, ash dump plate and control. Simple adjustment of the rate of feed, independent operation of any section of the grate by either hand or power and a safety attachment which prevents tramp iron or other foreign matter from interfering with action of the stoker are special features.

COMBUSTION ENGINEERING CORP'N, 43 Broad St., New York, will have booths 123-24-25-26. It will exhibit its pulverized fuel system including the pulverizing units, feeders, burners, air-cooled furnace walls and Raymond mill. Full size air-heater elements will be shown and a Lopulco furnace and boiler with electrical representation of flame. Various stokers will also be illustrated by drawings and detail parts.

COMMONWEALTH EDISON CO., 72 W. Adams St., Chicago, will have 6 spaces, Nos. 228 to 233. Here will be illustrated the extent of the company's operations in Chicago, the construction of its plants and the services which it renders to its customers.

CONNERY & CO., Second St., above Erie, Philadelphia, will display its Improved expansion stiffener as applied to breechings, uptakes, air and preheater ducts in booths 303-4. A section of breeching will be shown, 6 ft. wide, 15 ft. high and 25 ft. long, with two uptake connections; also provided with an Improved air-cooled damper, an asbestos-packed cleanout door and various types of roller bearings used with these dampers. Full details of the construction will be illustrated and explained.

CONTINENTAL VALVE & EQUIPMENT CO., 82 Herbert St., Framingham, Mass., will display its forged steel fittings in booth 28. This line will include box and flanged unions, reducing valves and pump governors of entirely new design and the special fittings for extra high pressures and temperatures.

COPPUS ENGINEERING CORP., Worcester, Mass., will be in booth 323. It will exhibit its undergrate blowers and turbo boiler feed pumps of single-unit design, also its Vano blowers and small steam turbines.

CRANE CO., 836 So. Michigan Ave., Chicago, will have booth 305, featuring a typical piping connection for a boiler carrying 400 lb. pressure. A motor-operated stop and check valve will be shown, with an electrically tripped emergency stop valve and a motor-operated gate valve. Various pipe joints for high-pressure service will be included, also samples of steel gate valves for pressures from 150 to 900 lb., relief valves and Crane pop safety valves.

THE CURTIS & CURTIS CO., Bridgeport, Conn., will exhibit in booth 52. Its pipe threading and cutting machine for sizes from ¼-in. to 16-in. pipe with self-centering vise and dies releasing automatically will be the main feature of the exhibit.

THE CUTTLER-HAMMER MFG. CO., 530 Grand Ave., Milwaukee, Wisc., will have its exhibit in booths 117-18. This will include one of the largest Dean valve control units in operation on the largest valve that can be put on the floor. Several control stations will be hooked up to operate this valve as in an actual plant. The plant is interlocking so that, when being operated from one control station, all other stations are locked out. Also the new Across-the-line a. c. motor starter will be hooked up, with an automatic breaking device on the motor to show at what load and speed the starter throws off current to protect the motor from burnouts. An attractive decoration will be a large oil painting of the cover of the new Dean control valve book, well worth seeing.

THE CUTTER CO., 1819 Hamilton St., Philadelphia, Pa., will have its display in booth 127, showing its V-Re-Lite switches consisting of an ITE circuit breaker in a specially constructed steel box for protecting motors, lighting and power circuits from overload and short circuits.

G. M. DAVIS REGULATOR CO., 422 Milwaukee Ave., Chicago, will exhibit a line of valve specialties for auto-regulation of air, steam and water in booth 357. All will be shown by illuminated sectioned models illustrating the prominent features of Davis construction and design. Principal features will be pressure-reducing and back-pressure valves, steam traps, float, balanced and relief valves, stop and cock valves.

THE DELAVAL SEPARATOR CO., 165 Broadway, New York, will have a showing of its purifiers for cleaning all kinds of oils. The form for cleaning fuel oil for Diesel engines is made vapor tight and the one for transformer oil is portable so that it can be taken to the job. The exhibit will be in booths 206-7.

DELTA-STAR ELECTRIC CO., 2400 Block, Fulton St., Chicago, will occupy booth 116 with an exhibit of its equipment for unit type standardized substations, including steel towers, choke coils, fuse mounting and switching units.

M. H. DETRICK CO., 140 So. Dearborn St., Chicago, will exhibit a new model of the Detrick flat suspended arch showing the latest type of end construction, in booth 333. Other arch details will also be shown and a model of Detrick sectional supported side wall construction for pulverized fuel and other high temperature furnaces. Arches and walls as installed will be illustrated by photographs and drawings.

THE DIAMOND POWER SPECIALTY CORP'N, Detroit, Mich, will show, in booths 317-18, a complete set up of an electrically operated automatic soot blowing system, comprising a main line steam valve, three motor-driven heads, a master controller for the main-line valve and the heads and a starting switch to operate the system. Operation of the main-line valve and heads by the master controller may be in any predetermined manner. Operation of the valve, units and drain valve will be by remote control. Improved drain valves, opening and closing automatically, calorized metal elements with welded Venturi nozzles, and the new Dialoy soot blower elements for abnormally hot locations will be shown, the Dialoy after use in temperatures of 1750 to 2000 deg.

JOSEPH DIXON CRUCIBLE CO., Jersey City, N. J., will have its exhibit in booth 237. An attractive display is planned of Ticonderoga and other special quality graphites, graphite greases and silica-graphite paints and primers. Of special interest will be the graphite greases for unusual conditions of pressure, temperature and operation offering difficult problems in lubrication. Dixon's spring oil and rust solvent will also be shown as well as aluminum-graphite paint and red lead-graphite primer, products adapted for power-plant equipment.

DODGE MFG. CORP'N, Mishawaka, Ind., will make a complete display of its equipment for power transmission including pulleys, shafting hangers, pillowblocks and couplings, in booths 31-32. A special feature will be loose pulleys, hanger and pillow block bearings equipped with the Timken roller bearing which reduces friction to a negligible quantity.

DRAKE NON-CLINKERING FURNACE BLOCK CO., 5 Beekman St., New York, will have booths 263-64 for a display of its block type furnace linings, bridge walls and kilns. These will be shown in the brands known as Standard, Utility, S-X and Carbo-glaze.

C. A. DUNHAM CO., 230 E. Ohio St., Chicago, will be in booths 351-52, with a display of steam specialties for low and medium pressures. Among these will be its radiator trap, its packless radiator valve, its float and thermostatic traps, return traps, pump governors, oil separators and damper control system.

EDWARD VALVE & MFG. CO., East Chicago, Ind., will be in booth 220 showing sectionalized specimens of its valves and fittings as specially designed for plants operating under severe conditions of high temperature and pressure.

EHRET MAGNESIA MFG. CO., Valley Forge, Pa., will be found in booth 314. It will display Ehret's 85-per cent magnesia pipe covering and blocks and high-temperature insulation in varying thicknesses and styles. The use of 85-per cent magnesia gives light weight, strong structure and permanent effectiveness. Details of the chemical and manufacturing processes of production will also be shown and photographs of large installations.

ELLIOTT CO., Jeannette, Pa., will occupy booths 20-1-2 with its associated companies, The Lagonda Mfg. Co., Springfield, Ohio, and Liberty Mfg. Co., Pittsburgh, Pa. Here will be shown representative products including a mechanical drive Kerr Turbine with specimens of buckets, packing and other features. Also cut-out models of 1-stage, 2-stage and combination ejectors, a 500-gallon building type deaerator, cut-out models of non-return valves, blowoff valves, twin strainers and receiver separators. Liberty and Lagonda boiler tube cleaners will be shown with sectioned models to demonstrate construction.

ERIE CITY IRON WORKS, Erie, Pa., will exhibit one of its coal pulverizers in operation in booths 271-72. This will demonstrate the unit method of pulverizing and feeding fuel and its application to moderate size boiler plants. Photographs will show installations that have been equipped.

EVERLASTING VALVE CO., 1 Exchange Pl., Jersey City, N. J., will occupy booth 43. Here the Boiler Draw-off Wylie Wilson Process will make its initial bow to the engineering world. It is a method for boiler blowoff which prevents shock to the boiler, lengthens the life of blowoff valves and piping and assures accurate measurements of the quantity blown down at each operation. Everlasting valves will supplement this feature, the Model X Tandem valve being a special feature. A special Everlasting valve for 450-lb. pressure and a line of Flatplug valves will be displayed.

FAIRBANKS-MORSE & CO., 900 Wabash Ave., Chicago, will exhibit its line of centrifugal pumps, electric motors, the type Y Diesel engine. Pumps and motors with ball bearings and details of the type Y engine will be a special feature in booths 112-13-14-19-20-21.

THE FISHER GOVERNOR Co., Marshalltown, Ia., will exhibit its pump governors, reducing valves, pressure regulators, lever and float valves and steam traps in booth 313. A special feature will be the new type 227A liquid level controller which has supplementary equipment allowing of remote control from any distant point. The devices will be shown in detail and by sectioned models to make clear the construction and principles of operation.

FOSTER-BOLTON Co., 549 W. Washington St., Chicago, will have booths 47-48. The exhibit will include the Wing turbine-driven blowers for undergrate service, Wing ventilating fans and exhausters, Featherweight unit heaters for heating factory space in high, medium and low ceiling types. Also will be shown the S. C. feed-water regulating system with type S valve for maintaining a constant differential pressure ahead of the feed-water regulator. The receiver drainage control with protected type seat and disc for 600-lb. pressure, the Navy type governor for high-pressure steam turbines and type O governor for turbine-driven pumps will be included.

FOSTER ENGINEERING Co., 109 Monroe St., Newark, N. J. This company will show its non-return valves and pressure regulating valves in booth 353, also the Foster flexible joint. The non-return valve is for use with steam at 400 lb. pressure and 800 deg. F., while the flexible joint is provided with a spring follower to keep it packed tight at all times.

THE FOXBORO Co., INC., Foxboro, Mass., will exhibit its instruments for indicating and recording pressures, temperatures, liquid levels and humidity and their mounting on panels in booth 434. The Foxboro differential type liquid level gage will be shown in working order. Instruments will be shown segregated according to the type of plant in which they can be used; for the oil-burning plant, recording and indicating pressure gages and thermometers for the fuel line; for the coal-burning plant, recording pressure gages, indicating and recording draft gages and thermometers for stack gases, CO_2 recorders and other boiler instruments. On panels will be mounted instruments of general interest to the factory and power plant engineer such as recording and non-recording temperature, pressure and humidity controllers, recording psychrometers, engine room and gage board clocks and the turbine-bearing thermometer for measurement of bearing-oil temperatures, specially mounted to eliminate trouble from vibration of the bearing.

FREEMAN MFG. Co., Racine, Wisc., will have booth 415 in which it will exhibit its water-tube and horizontal tubular internally fired boilers, showing details of design and construction and photographs of typical installations. It will exhibit also examples of special stack, tank and plate work construction.

FULLER-LEHIGH Co., Fullerton, Pa., will have a comprehensive exhibit in booths 9-10-11-12. It will include, horizontal and vertical burners for powdered fuel; the Randolph waste heat dryer; a working model of the Fuller-Kinyon conveying system for pulverized materials, also of the automatic switching valve; the Fuller-Lehigh pulverizer mill in a model, also working model of the Fuller well-type furnace; single screw feeder for pulverized fuel and model of the Fuller-Bonnot unit mill; enlarged photographs of equipment and installations made by this company.

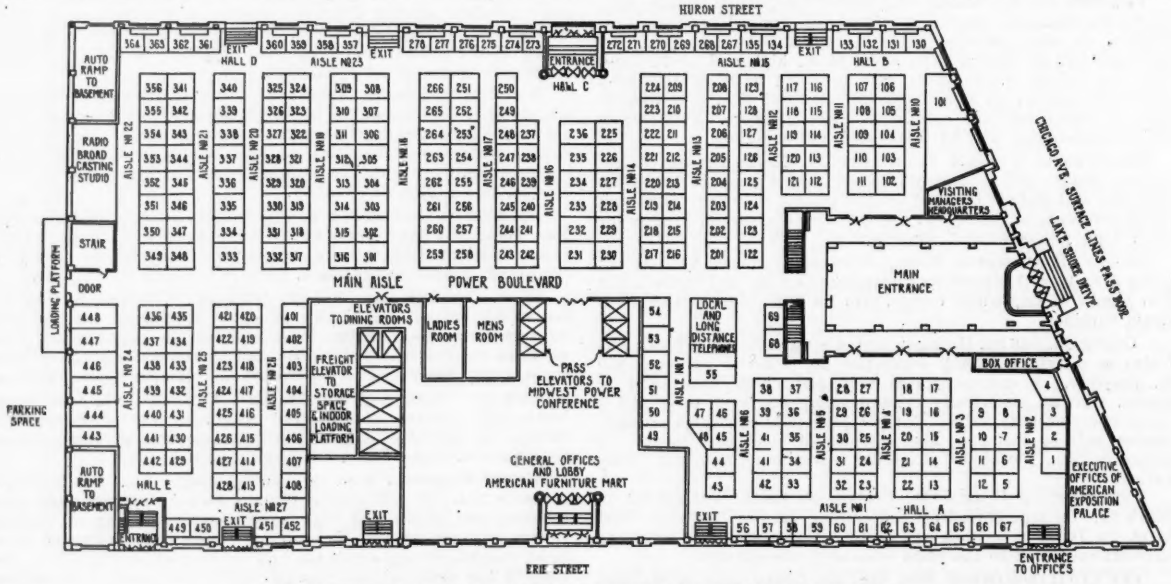
FURNACE ENGINEERING Co., 5 Beekman St., New York, will show its Simplex unit pulverizer in booths 263-64. It will demonstrate the use of revolving hammers and the action of air separation by means of a fan blast. Capacities of the units are from 1500 to 15,000 lbs. an hour.

GENERAL ELECTRIC Co., Schenectady, N. Y., will specialize its exhibit in booths 229-30-31-32 on flow meters, brush-shifting motors for alternating current, air coolers for turbine-generator ventilation and on an extensive line of motor and control equipment. Flow meters will be in operation on steam from an electrically heated boiler.

GRAVER CORPORATION, East Chicago, Ind., will have booth 308 in which it will display a working model of Graver water softeners, also large colored drawings showing the details of construction and installations of softening plants.

HAGAN CORPORATION, Pittsburgh, Pa., will exhibit in booths 331-32, its combustion control equipment, regulators for stokers, fans and draft, also the Hagan steam purifier and boiler water conditioning apparatus. A working model will show the compensated draft system in connection with a model furnace to reproduce conditions as they exist in a plant. The steam purifier will also be shown in operation, demonstrating how completely moisture and impurities are removed from the steam. How scale is formed and the means of preventing it, as developed by a four-year investigation in cooperation with the Bureau of Mines, will be demonstrated and explained by the company's engineers.

HARBISON-WALKER REFRACTORIES Co., Farmers Bank Bldg., Pittsburgh, Pa., will show a full line of its refractories in brick, block and cement form for use in furnaces and lining of high-temperature equipment. Their exhibit will be found in booth 328.



ALL EXHIBITS WILL BE ON MAIN FLOOR OF EXPOSITION PALACE

HEINE BOILER Co., St. Louis, Mo., will show, in booths 253-54, its seamless forged steel sectional header, a new type of seamless forged steel drop leg sectional header, and large photographs showing typical installations of all types of Heine boilers taken in the Midwestern territory. The seamless headers are forged by a special process and the ends closed in such a way that metal is upset to give increased bearing surface for connecting nipples. Sides are slightly hollowed so that, when nested, they retain the packing seal against air leaks.

HIMELBLAU, AGAZIM & Co., 30 N. Dearborn St., Chicago, will occupy booth 323. Included in the exhibit will be power plant and industrial equipment; Engelhard pyrometers, regulators and electric thermometers; Sterling heating specialties; Coppus blowers and boiler feed pumps; Carew-Greene internal steam separators; Witherup cork packing; Korfund cork isolation material; Davis traps, and Frank heaters and coolers.

THE M. A. HOFFT Co., 814 W. Washington Ave., Indianapolis, Ind., will show its National flat suspended arch in which each tile is carried on a separate hook so that it may be easily replaced while the furnace is operating. There will also be a National hand-operated stoker combined with the flat arch into an illustrative setting for a 150-h. p. boiler. The exhibit will occupy booth 321.

HOOSIER ENGINEERING Co., Indianapolis, will have a display illustrating transmission lines and substations which it has constructed, showing the methods and equipment which its organiza-

tion furnishes for such work. Motion pictures and photographs will be used, some of them of the Milwaukee-Twin Falls Line of the Milwaukee Electric Ry. & Lt. Co. The Hoosier Engineering Co. furnishes organization and equipment for erection work, but sells no materials.

C. W. Hunt Co., Staten Island, N. Y., is to have booth 335. Its exhibit will include pivoted bucket conveyor system, industrial railway equipment, skip hoists, larries, coal crackers and ash gates.

Hyatt Roller Bearing Co., Newark, N. J., will show its anti-friction bearings as adapted for transmission equipment and for power plant and industrial machinery in booths 432-33. Application will be shown to cranes, conveyors, hoists, trucks, motors, fans and other uses.

The Hydraulic Press Mfg. Co., Mt. Gilead, Ohio, will have its complete line of drop-forged steel fittings for high pressure and temperature, also its valves for the like conditions, with body made of drop-forged steel. These valves have forged-steel yoke, full steam opening and body of uniform section, with renewable bevel disc and seat. The booth is 255.

Ilg Electric Ventilating Co., 2850 No. Crawford Ave., Chicago, will exhibit its new electric unit heater with resistance coil elements. A full size unit will be shown and demonstrated. Also will be exhibited an Ilg power roof ventilator which works regardless of wind or weather conditions to exhaust a definite amount of air at all times. A self-cooled motor-driven propeller ventilating fan and a new variable-speed, 3-phase alternating current motor will be included in the display in booth 345.

Illinois Engineering Co., 21st St. and Racine Ave., Chicago, is to show steam and heating system specialties in booth 250. Cut samples of valves, for pressure reduction and control of back pressure, radiator traps, steam traps, also a working vapor heating system and an operative glass-model steam trap to show valve action will be found in the exhibit.

Instant Water Heater Co., Manchester, Ind., will have an exhibit of its heaters in the booth of Barrett-Christie Co., No. 338.

International Filter Co., 333 W. 25th Pl., Chicago, will demonstrate by a working model the chemical mixing, feeding and proportioning of an International hot-flow softener in booth 435. The balance of the softener will be shown diagrammatically. Also a model will be exhibited of the company's Zeolite water softener, and a display of photographs, diagrams and charts illustrating various adaptations of International purification equipment for water to power plant requirements. This equipment is of six different types and filters are of four types. There is also apparatus for sterilizing, dry or wet chemical feeding, removal of color, iron or oil for water treatment. Instruments such as flow controllers, head gauges and the like will be included in the display.

The International Nickel Co., 67 Wall St., New York, will have a display consisting of representative samples of articles made from Monel metal as used in the power industry. The exhibit will be in booths 64-65.

Iron Fireman Corporation, 617 Fulton St., Chicago, Ill., will be found in booth 416, exhibiting its automatic furnace for heating plants, in sizes up to 200 hp., a new development which is designed to overcome difficulties in handling low-pressure plants.

Jenkins Bros., 80 White St., New York, will have a display of valves, in booth 56, arranged as in actual use, with glass port holes so that action of the fluid can be studied as the valves are opened and closed. Types shown will be swing check Y blowoff, gate, cross, angle, rapid action and horizontal check. Valves with regrinding feature, hard bronze for superheat, automatic stop and check valves for boiler outlets, Jenkins Bros.' sheet packings and rubber pump valves will also be exhibited.

W. A. Jones Foundry & Machine Co., 4401 W. Roosevelt Rd., Chicago, will have, in booth 236, an exhibit of its spur-gear and its worm-gear speed reducers; Lemley friction clutches, and various other of its products such as cast-iron pulleys, gears, pillow blocks and hangers.

Kelley Valve Co., Muskegon, Mich., will have an exhibit of standard and high-pressure valves in booth 361.

M. W. Kellogg Co., 90 West St., New York, will have its exhibit in booth 220, where will be found samples of forge-welded nozzles and piping joints for high-pressure, also forge-welded headers. A special feature will be forge and hammer welded tongue and groove pipe ends with swivel flanges.

Ladd Water Tube Boiler Co., First National Bank Bldg., Pittsburgh, Pa., will occupy booth 419, with photographs, prints and data concerning all types of Ladd water-tube boilers. A special feature will be the Ladd patented baffle tile used in all its boilers.

The Leavitt Machine Co., 11 E. River St., Orange, Mass., will be found in booth 446. Dexter valve reseating machines will be demonstrated as used for all sizes of gate, globe and pump valves.

Ernest E. Lee Co., 115 So. Dearborn St., Chicago, will have, in booth 446, a variety of products of the firms which it represents. This will include American ring coal crushers, the A-S-H ash sluicing system, Roturbo centrifugal pumps, the Copes feedwater control system, Leavitt valve reseating equipment, Nitrose metal preserving paint, Uehling recording and indicating instruments, the Dings magnetic separator and Atwood & Morrill relief valves.

Liptak Fire-Brick Arch Co., Mexico, Mo., will exhibit details of its furnace construction in booth 356. A section of Liptak air-cooled furnace walls, another of solid furnace wall construction and a model of Liptak double suspension arches will be among the features. The support of walls by vertical buckstays and castings kept away from the zone of intense heat gives protection to the supports, sectional construction of the lining wall and provision for expansion in each section.

Locomotive Terminal Improvement Co., Chicago, Ill., will be found in booth 23, with a display of its line of steam specialties for cleaning boilers.

Lumen Bearing Co., Buffalo, N. Y., will have a display of its bearing metals and special bearing material in Booth 338, also samples of the bronze castings which it produces.

The Lunkenheimer Co., Cincinnati, O., will have in its display, booths 234-35, various types of valves and engineering appliances including steel valves of recent design for pressures up to 900 lb. and temperatures to 750 deg. F. These will be shown in sizes up to 30-in., and in gate, globe, check, non-return, blowoff and reheat types. Of outstanding interest will be a 10-in. W. S. P. gate valve for 400 lb., and a 6-in. W. S. P. valve for 900 lb., both electrically operated. A selection of the latest design, iron body, bronze-mounted gate valves of both outside screw and yoke and inside screw type will be exhibited and a group of small valves and bronze apparatus of the company's make.

Manistee Iron Works, Manistee, Mich., will show, in booth 448, rotary jet condensers and the Roturbo centrifugal pumps for special power plant service.

Manning, Maxwell & Moore, Inc., 100 E. 42nd St., New York, will have an exhibit consisting of Ashcroft gages, of all kinds, from the smallest and least expensive iron and steel cased up to large brass cased master gages for 2400 lb. pressure, all mounted on display panels; Consolidated pop safety valves, from the house-heater type for pressures up to 15 lb. up to steel safety valves for 1200 lb. on large power boilers; Hancock sectioned inspirators and injectors, Hancock valves in flanged bonnet type from ¾-in. to 7-in. for high pressures, bronze valves for all uses and some special types such as drum head, stop and check; Metropolitan injectors and ejectors. The exhibit will be in booths 265-66.

Marion Machine Foundry & Supply Co., Marion, Ind., will display various types of rotary soot blowers for tubular and water-tube boilers in its booth 445. A special additional feature will be the Marion Gulf Stream water heater, especially for power plant use.

Merco Nordstrom Valve Co., 347 Peoples Gas Bldg., Chicago, will show its lubricated plug valve with lubricant reservoir in the valve stem and used under pressure to relieve the plug from its seat before operation and spread a film of lubricant over the working surfaces. The booth will be 428.

Midwest Piping and Supply Co., 1450 So. 2nd St., St. Louis, Mo., will have a display of its welded headers, difficult pipe bending and pipe joints in booth 401. In these joints, no gaskets are needed, as they are made with ball and socket action. They are especially adapted for high temperatures and pressures and are for use between sections of piping, from pipe to fittings or valves and between fittings and valves. Van Stone and Sargol joints will also be shown.

Moore Steam Turbine Corp., Wellsville, N. Y., will exhibit its single-stage turbine mounted on a base plate and connected by a Moore flexible coupling to one of its 2-stage, double-suction centrifugal pumps. Parts of the turbine and pump will also be shown to illustrate the design and construction. The exhibit will be in booth 220.

Mueller & Co., Decatur, Ill., will have an exhibit of its line of metals and steam specialties in booth 53.

J. W. Murphy Co., 108 So. La Salle St., Chicago, Ill., will have a display of its electric meters in booth 109.

Nash Engineering Co., South Norwalk, Conn., will show, in booths 301-2, its Jennings Hytor Vacuum and condensation pumps for drawing air, gas and condensate from heating systems, also the Hytor sewage ejector and circulating pumps for hot water and condensing systems.

Nice Ball Bearing Co., 30th and Nicetown Lane, Nicetown, Philadelphia, Pa., will show a complete line of its industrial ball

bearings of annular, combination, thrust and plate types, featuring especially its pressed steel ball-bearing caster, in sizes from 3-in. to 6-in., with dust cover and stationary hub cone. The exhibit will be in booth 36.

THE NITROSE CO., Peoria, Ill., will have booth 448 and a display of metal preservative paint for protection against acids, brine, ammonia, abrasion and extremes of heat and cold.

NORMA-HOFFMAN BEARINGS CORP., Stamford, Conn., will show a complete line of open and closed type ball bearings, roller and thrust bearings and the Norma minimeter for measuring parts of bearings to extremely close limits. Operating models will illustrate the principal features of various types of bearings and a flywheel mounting will demonstrate the low friction of sensitive, quiet-running ball bearings. The exhibit will be in booths 134-35.

NORTHERN EQUIPMENT CO., Erie, Pa., will show the Copes boiler feed water regulator in booth 447. A moving display will illustrate the action and the relation between boiler load, boiler water level and the automatic control of feed water input which gives a definite feed valve opening for a given water level. When steam demand falls off, the regulator increases the opening in the control valve, raising the water level and storing heat in the boiler for the next increase in demand. When the peak load comes on, rate of feed is temporarily cut down so that the boiler steams at maximum. The display will also include Copes control valves, pump governors and valve movement indicators.

NORTON CO., Worcester, Mass., will have in booths 45-46 the exhibit of its Refractories Division grouped about a section of a Riley lateral retort stoker with Crystolon bricks at the clinker line and in the bridge wall, set in Norton refractory cement. Crystolon bricks are used at these points because of their resistance to clinkering and to abrasive action of the fuel. There will also be a group of typical heavy refractory pieces including breaker bricks as used in gas and oil-fired heat-treating furnaces to take the direct blast of the flame, hearth plates, alundum enameling muffle section as designed by the Ferro Enamel Supply Co., Dressler tunnel kiln section, Waite & Davey air-cooled furnace block and Norton refractory cements which have been developed to meet the requirements of spraying, painting, pouring, troweling or ramming into position. These cements are composed of alundum, Crystolon and electrically fused magnesia, which, combined with carefully chosen bonds of high refractory properties, provide a complete range and variety of cements which are mixed with water to working consistency.

WM. W. NUGENT & CO., 410 No. Hermitage Ave., Chicago, will occupy both 42 with a display of a continuous oil filtering system for 300 gal. an hour, motor-driven rotary pumps, sight-feed valves with glass and strainers removable for cleaning, telescopic oiling devices and threadless, compression union fittings.

R. D. NUTTALL CO., McCandless & Harrison Aves., Pittsburgh, Pa., will have a reception space in booth 205, where it will exhibit Nuttall BP tough hard gears and pinions of various types for use in street railway, mining and industrial fields.

NUWAY BOILER & ENGINEERING CO., 53 W. Jackson Blvd., Chicago, will exhibit a glass model of the Nuway boiler in booth 326. This will show the construction of circulating space and, the unretarded circulation and method of eliminating end circulation; also why this boiler can be operated at high overloads yet deliver dry steam and why it can respond quickly to fluctuating loads. Illustration will also be given of the company's work in construction of steel stacks, tanks, plate work and breechings.

PENNSYLVANIA CRUSHER CO., Stephen Girard Bldg., Philadelphia, Pa., will have in booth 436, working models of the Bradford Breaker and of the Armorframe single-roll types of coal crushing and preparation equipment as used in both stoker-fired and pulverized fuel power plants. The Bradford type is used for large stations to bring the coal to uniform size suitable for stokers or for feed to pulverizers, at the same time removing foreign matter. The Armorframe has capacities up to 300 t. an hour but is more largely used for plants requiring 5 to 100 t. an hour. Photographs will also show the adaptation of the Steel-built hammer-mill crusher in coke, cement, lime and stone plants.

PHILLIPS, LANG AND CO., 431 South Dearborn St., Chicago, will display the steam specialties of the companies which it represents in booth 335.

PITTSBURGH PIPING AND EQUIPMENT CO., Pittsburgh, Pa., will have its display in booth 49, where will be shown the Sargol-Weld patent joint, without gasket and with special welded seal, also samples of its welding work for branch pipes and heaters, especially for high-pressure systems.

PLIBRICO JOINTLESS FIREBRICK CO., 1130 Clay St., Chicago, has booths 223-24 and will show a model of a front door arch with illustrations of various types of installations demonstrating the use of its product for building and lining furnaces. In connection with the exhibit, a convention of representatives will be held for the entire western territory including the Pacific coast states.

WM. A. POPE, 26 N. Jefferson St., Chicago, will have examples of its heating specialties and high-pressure piping construction in booth 208.

THE WM. POWELL CO., Cincinnati, Ohio, will have its display in booth 213. This will include a complete line of iron, brass and steel White Star valves, also the Model Star regrinding valve for working pressures up to 200 lb.

POWER PLANT ENGINEERING, Chicago, Ill., will have a reception booth and rest room for its friends in booth 122, at the main entrance.

POWER PLANT SPECIALTY CO., 440 So. Dearborn St., Chicago, Ill., will show its method of feed water treatment and the equipment which it installs in booth 339.

POWERS REGULATOR CO., 2720 Greenview Ave., Chicago, will demonstrate its system of temperature control for heating plants, water heaters and industrial equipment. This will include spring type and lever type regulators, Powers thermostats and the auxiliary equipment for operating temperature control systems. The exhibit will be in booth 355.

POWER SPECIALTY CO., 111 Broadway, New York, will show in booths 315-16, its Radiant Type superheater with forged steam elements. The exhibit will demonstrate the construction and use of the Foster Convection Type superheater and of the Foster economizer, which are built as integral parts of the boiler structure.

HENRY PRATT CO., 2222 So. Halsted St., Chicago, will be located in booth 336 with a display of Phillips coal spout swinger in operation, models of the Phillips expansion joint and the Pratt coal valve.

QUIGLEY FURNACE SPECIALTIES CO., INC., 26 Cortlandt St., New York, will have in booths 449-50, Hytempite cement for laying up fire brick and bonding refractory materials, Ganisand, a refractory ganister used with Hytempite for lining and repairing furnaces and making special shapes, Quigley refractory gun for shooting pre-mixed plastic refractories at high velocity against wall or arch in construction and maintenance work, Quigley acid-proof cement for bonding and surfacing acid-resisting masonry, Quigley Triple-A solutions and enamels to form protective coatings on iron, steel and other metals against corrosion and for waterproofing and decorating concrete, brick, stone or wood surfaces. These enamels will be shown in black and colors. The booth will be arranged as the interior of a boiler room and daily demonstrations will be given.

RACINE TOOL & MACHINE CO., Racine, Wis., will exhibit its high-speed reciprocating metal-cutting saws, also its duplex band saw for cutting soft and hard metals at high speed. The display will be in booth 41.

RAILWAY AND INDUSTRIAL ENGINEERING CO., Greensburg, Pa., will have an exhibit in booths 209-10, consisting of its latest types of air-break, horn gap switches. The vertical-opening is known as TTL (Tail Twister) for voltages from 15,000 to 73,000. The IB-2 is a side opening switch. The RL gang-operated disconnecting switch shows the trend for either manual or remote control as away from the single pole hook switch. A 3000-amp. switch will be part of the display. A motor-operated switch exhibit will show the details of the mechanism and relays, contactors, limit and signal-switches. Bus supports and bus bar fittings will also be shown.

RAMSEY CHAIN CO., INC., Albany, N. Y., will occupy booth 44, where will be shown a complete line of Ramsey silent chains, sprockets and pinions. An interesting demonstration will be shown of nine chains of various pitches, freely suspended upon 17-tooth sprockets which turn at 1200 to 1400 r.p.m., yet the chains assume the same form as at rest. Also will be shown a compensating joint in a large wooden replica to demonstrate the roller bearing of one pin upon the other in the chain action.

READING STEEL CASTING CO., Bridgeport, Conn., will show its cast steel fittings in flanged type for pressures of 150 to 900 lb. and in screwed type up to 600 lb. Also its cast steel globe and gate valves for 400 lb. and a motor-operated valve for the same pressure. In the exhibit, booths 362-63, will be a complete line of iron-body and of bronze-body globe, angle, gate and check valves and photographs of typical installations of the company's products.

REEVES PULLEY CO., Columbus, Ind., will have an exhibit of its variable speed transmission in operation in booth 238, with 4 to 1 speed ratio and remote electrical control by means of which speed may be varied from a remote push-button station. Also will be demonstrated mechanical remote control by means of "fast" and "slow" pull cables. A compact individual motor drive, consisting of a constant-speed, alternating-current motor mounted on the frame of a Reeves variable speed transmission and connected by silent chain and sprockets, will have the new steel-link V belt on the transmission.

REN MANUFACTURING Co., 671 Main St., Winchester, Mass., will show in booth 108, the Ren-Lock for preventing the theft of electric light bulbs, consisting of a coiled spring and a grooved ring. It can be attached to standard brass, porcelain and weatherproof sockets by use of a special punch and the bulb can be removed only by breaking the glass for which a special bag is provided.

REPUBLIC FLOW METERS Co., 2240 Diversey Parkway, Chicago, will have an extensive display in booths 130-1-2-3. This will include its entire line of Republic instruments for measuring steam flow, boiler performance, water, coal, air and gas consumption, CO_2 recorders, draft indicators and recorders, pyrometers and liquid level measures. A new development will be the motor-driven CO_2 recorder which obviates trouble from dirty water and carries a 90 days' supply of KOH.

Another feature will be a multiple draft indicator with all readings on one eye level and permanent zero setting. The liquid level indicator is an electrical device, so that the record of levels in reservoirs and tanks may be read at a distant point.

THE RIC-WIL Co., Union Trust Bldg., Cleveland, O., will be located in booth 320, where it will display full size samples of the Ric-wiL Loc-liP conduit for insulating underground steam and water pipes, four types being designed to meet specific conditions. The Ric-wiL method of steam distribution will also be demonstrated by a complete miniature system.

RILEY STOKER CORPORATION, Worcester, Mass., will have booths 247-48-49, and will exhibit a full size Riley Atritor, opened to show details of construction, and a full size Harrington traveling-grate stoker, especially adapted for western coals.

RISHER FIRE BRICK Co., West 18th and Seward Sts., Chicago, Ill., will show its fire brick in various grades and shapes in booth 354.

SARCO Co., INC., Woolworth Bldg., New York, will have its thermostatic control apparatus, steam traps and appliances for steam heating in booth 38. A special feature will be its new No. 9 self-adjusting trap, which is designed on the balanced pressure principle. The pressure within the thermostatic or motor element balances against the steam pressure so that the trap is self-adjusting from pressure of 0 to 100 lb. Tubing or bellows in Sarco thermostatic appliances is of seamless bronze corrugated in helical or spiral form.

SAUERMAN BROS., 438 So. Clinton St., Chicago, Ill., will occupy booth 327 with a working model of their drag scraper system for stocking out and reclaiming coal, a miniature representation complete in every detail, showing the use of the same drag scraper for storing and reclaiming.

THE S-C REGULATOR MFG. Co., Fostoria, Ohio, will have its display in booth 48. This will include feed-water regulators and pump governors, showing improvements in standard regulators for pressures under 400 lb. and special developments in high-pressure regulators for 400 to 600 lb.

A feature will be the S-C Master Control for valves, pressures and boiler room equipment, to handle special conditions, also pump governors for systems carrying pressures up to 700 lb.

SCHUTTE & KOERTING Co., 12th and Thompson Sts., Philadelphia, Pa., will show in booth 349, its line of condensers, oil and air coolers, pumps, special valves and cooling devices for condensing water. Some of the apparatus will be a multi-jet condenser in operation at no vacuum demonstrating the action of the water jets; a single-jet eductor condenser in operation under vacuum showing entrainment by the water jet; a sectional oil cooler; section of a Radiafin, oval-tube generator air cooler; bronze and forged steel valves and toggle stop-check valve; spur and herringbone type of gear pumps; spray nozzles and miniature spray clusters; sectional injector; and steam jet thermo compressor.

SIMPLEX VALVE & METER Co., 68th and Upland Sts., Philadelphia, Pa., will have in operation one of its boiler feed meters as used in many of the larger power plants. These meters are of venturi type and are made in indicating form, as indicators and recorders, or as indicating, recording and totalizing meters. They are adapted for metering feed water, condensate, circulating water or industrial supplies, hot or cold and in any quantities. The display will be in booth 360.

SKF INDUSTRIES, INC., 165 Broadway, New York, will occupy booth 54, with an exhibit of all types of ball-bearings, including radial and thrust, double row, self-alining bearings with balls and with rollers and applications of ball bearings to hangers and pillowblocks.

D. H. SKEEN & Co., 53 West Jackson Blvd., Chicago, Ill., will have an exhibit occupying seven booths, numbers 214 to 220. The display will include Mercon Regulators for constant excess pressure and constant back pressure, also for constant reduced pressure, special features being the absence of stuffing boxes, weights or springs.

Also will be shown the forge-welded nozzles, piping and headers of the M. W. Kellogg Co., the Ljungstrom air preheater, Edward high-pressure steam valves, Moore steam turbines and centrifugal pumps, Alberger heaters and heat exchangers and the Stets water level controller in cutaway models, showing the action of the controller.

SKIDMORE CORPORATION, 1535 Dayton St., Chicago, will have an exhibit of its vacuum pumps for condensing and heating systems in booth 420.

M. B. SKINNER Co., 558 Washington Blvd., Chicago, will have an elaborate display of its entire line of specialties in booth 59. This will include pipe joint clamps for stopping leaks where the pipe is screwed into a fitting, emergency pipe clamps for repairing leaks in pipe lines, service saddles for making connections to piping, pipe saddles for use where permanent outlets are desired, collar leak clamps for permanently stopping leaks about collars and couplings, pipe line clamps for repairing long splits, flange clamps for stopping leaks through flange couplings, gasket cutters, reseating tools for globe valves and bibb cocks, flue cleaner rods, pipe benders, and hickeys for bending pipe cold without kinking.

STANDARD OIL Co., (IND.), 910 South Michigan Ave., Chicago, will display its oils and greases and demonstrate the method of adapting lubricants to the work required and of giving to oils and greases the properties needed for special conditions. The exhibit will be in booth 252.

STANDARD POWER EQUIPMENT Co., 925 Monadnock Blk., Chicago, will show the centrifugal and reciprocating pumps of the American Steam Pump Co., in steam and power-driven types, also its sand pumps. Ric-wiL products for underground steam and water distributing systems will be displayed. Hytor turbine vacuum pumps, low-pressure air-compressors and Jennings-Nash Hytor combined vacuum and low-pressure boiler feed pumps, centrifugal pumps and sewage ejectors. Some of the equipment will be shown in operation in booths 319-20, 329-30. Reliance feed water heater and purifier and Stickle steam traps will also be shown.

STERLING ENGINEERING Co., 419 3rd St., Milwaukee, Wis., will be found in booth 323. Its display will include Sterlco thermostatic self-cleaning radiator traps, packless radiator valves, venting devices for steam heating systems and Sterlco-Roys temperature controls. This Thermotrol has a valve, controlled by a thermostat, in place of the usual radiator valve, so as to regulate within extremely small temperature range. It is so simplified that it can be used in any building from the smallest residence to the largest hotel or office structure.

STROM DIVISION, Marlin-Rockell Corp., 4527 Palmer St., Chicago, will have a variety of types and sizes of Strom ball bearings in booth 27. These will include single and double row radial, angular contact and thrust types. A notable feature will be the Super-Strom, a new bearing, just on the market. Display boards will show the process of producing of a bearing from raw stock to finished product. To demonstrate the low friction of these bearings a Pyle-National turbine-generator set will be fitted with fan blades and started and driven by an electric fan placed 2 ft. away. Also a model with one shaft having plain bearings and another ball bearings will be arranged so that visitors can compare the frictional resistances.

THE STRONG SCOTT MFG. Co., Minneapolis, Minn., will demonstrate the action of its Unipulvo System for coal pulverizing and burning equipment in booth 58. This is a self-contained unit for serving the individual boiler, passing coal as large as 3-in. lumps from hopper to crusher, with breaker plates arranged to yield and allow uncrushable material to pass and be ejected. Around the rotor chamber is a blanket of stationary coal, the rotor, of swing hammer type, revolving on ball bearings in the chamber with clearance all around. This acts as a closed end fan, drawing in all air required for combustion and sweeping it around with the coal in suspension, discharging it into the separating chamber at the top whence the fines are blown to the burner and coarse particles returned for further reduction. Because of this intense air action, very wet coal can be pulverized.

B. F. STURTEVANT Co., Hyde Park, Boston, Mass., will occupy booths 422-3-4 with an exhibit of fans, blowers, turbines, motors, economizers and air preheaters. It will demonstrate especially its latest design of high-speed fan for forced draft, direct driven by a steam turbine. For ventilation, a Silent fan direct-driven by electric motor will draw air through an air washer and other features will be a turbo undergrate blower for forced draft, fans for induced draft and the propeller type fan, motor driven for ventilating purposes. Steel economizer tubes, lead coated to withstand high pressure and corrosion, also steel discs to extend the tube surface, which are so tightly attached that the indentation shows on the inside of the tube, will be on display.

Sections will be shown of the plate type air preheater; also Cindervane fans, especially adapted for removing solid matter from flue gases.

THE SUPERHEATER Co., 17 East 42nd St., New York, will occupy booths 259-60. Two units will be shown from one of the Elesco superheaters now being built for the Illinois Power &

Light Co.'s Des Moines station for two Heine cross-drum boilers of 1500 hp. each. These are to give 250 deg. superheat at 385 lb. when operating at 225 per cent rating. The units will be shown connected to saturated and superheated steam headers to illustrate the application of the clamp and ball joint used for this purpose. Also the units will show the method of joining mill length tubing into a continuous tube by means of a forged return bend, giving great flexibility in the proportioning of the superheating surface. Photographs of typical boilers will show the location of superheaters.

W. O. & M. W. Talcott, Inc., 91 Sabin St., Providence, R. I., will have in booth 322, its various styles of belt fasteners, showing the breaking strain of each style when used on leather or rubber belting. Application of Talcott-Wilson belt hooks will illustrate the smoothness of such joints, which have no projecting points or ends, one fastener being usable repeatedly in shortening a belt. Clinching belt hooks for rubber and woven transmission or conveyor belts from $\frac{1}{8}$ up to 1 in. thick will be displayed, also a new plate and rivet fastener to be inserted between the middle plies of a belt leaving the outer surface on each side smooth for engaging the pulley face.

The Timken Roller Bearing Co., Canton, Ohio, will show a miniature reproduction of its steel mill, including electric furnaces, 35-in. blooming mill, 22-in. bar mill, piercing mill and 10-in. merchant mill. By this means will be shown the various steps in the manufacture of Timken roller bearings. This will be in booth 101. The improved Timken bearing will also be shown and demonstrated. This has the large end of the roll at right angles to the center line of the roll and has the rib of the cone slightly undercut so that contact with the large end of the roll is in two areas, giving perfect axial alinement and line contact between surfaces of roll and cone. The cage serves only to maintain proper spacing of rolls about the cone, since the rolls are self-alining. Simultaneous punching of all cage pockets and swaging of lateral edges of ribs to conform to the contour of the rolls, and an inwardly turned flange on the smaller side of the cage are improvements making for lowered friction and quiet running even at high speeds. Use of a special nickel molybdenum alloy steel reduces wear and adds to the life.

Troy Engine & Machine Co., Troy, Pa., will have in booth 221, a display showing the construction of its engine and the details of the lubricating system used on the engine.

Uehling Instrument Co., 473 Getty Ave., Paterson, N. J., will be found in booth 446 with a display of its waste meter for showing fuel wasted up the chimney, CO_2 and flue gas temperature are recorded on one chart showing whether proper attention is paid to getting higher CO_2 at peak load periods when flue temperature naturally rises. The temperature record indicates when soot was blown or scale removed, also by-passing of gases by leaky or broken baffles. The Uehling combined barometer and vacuum recorder will also be shown.

Union Iron Works, Erie, Pa., will show, by a series of enlarged photographs, installations and details of the Union water-tube boilers in horizontal long-drum and cross-drum types, also vertical bent-tube boilers and its Universal return flue fire-tube boiler. The exhibit will include a number of distinctive and interesting features in boiler design and will be found in booth 308.

Vastine Sales Corp., 205 West Harrison St., Chicago, will show, in booth 325, a Furnace Fire Observer to be inserted in the door or side wall of the furnace, enabling observation of the condition of the fire and brick work at all times without letting cold air into the furnace or allowing heat to escape. The device has an air-cooled casing with a glass front and permits such clear vision that photographs of furnace conditions can be made, if desired.

The Vulcan Soot Cleaner Co., Du Bois, Pa., will be in booth 346. The Vulcan self-contained, valve-operating head, the improved ratchet operating head and heat-resisting soot cleaner elements will be special features of the exhibit. In the valve-operating head, the valve is integral with the head and is a swinging disc, positive action, self grinding and operated by the one handle or chain which moves the rotatable element. The ratchet head gives a step-by-step movement, thus avoiding spinning of the element.

Walsh Fire Clay Products Co., 360 N. Michigan Blvd., Chicago, will show its products, including all kinds of firebrick for furnace lining and construction in booth 25.

The Walsh & Weidner Boiler Co., Chattanooga, Tenn., will have its exhibit in booth 350. Two seamless forged steel sectional boiler headers will show its standard construction on which the A. S. M. Code allows a pressure of 480 lb. These will be part of an 18-tube high boiler and will show details of handholes, plates and gaskets. A section of 54-in. diameter steam drum, built for 425 lb. working pressure, will show construction details and materials for baffle construction will be displayed. Blueprints will show various types of settings for these boilers.

Walworth Co., Boston, Mass., will feature Walworth Sigma steel fittings and valves in booths 267-70. Several sizes of valves will be shown for high pressure and high temperature and a 4-in., 400-lb. tee on which the recent notable distortion tests were made. There will be included castings showing special features in connection with the processes in making steel castings, also X-ray pictures illustrating defects in steel castings.

Warren Webster & Co., Camden, N. J., will be found in booths 275-6. The main feature of the exhibit will be a working model of a Webster type R Modulation System of steam heating with all essential features shown in glass pipe. Operation of the system will show the working of the boiler return trap, the vent trap and vent valve, modulation supply valves and Sylphon traps. It will show what occurs inside a piping system and engineers will explain why the apparatus works as it does and why it should.

Western Union Telegraph Co., will have a station for the accommodation of patrons, receiving and distributing messages in booth 51.

Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. In this company's booths, 201-2-3-4, will be found examples of the latest developments in small turbine-driven generating sets and turbines for mechanical drive, also steam-jet air ejectors, the twin air ejector with surface type inter-cooler and after-condenser, being specially featured. A Type LV Autovalve Lightning Arrester will be shown in operation, demonstrating the glow discharge principle and its specially fast operation.

A feature will be the Sharples Super-Centrifuge designed particularly for reconditioning the insulating oils for transformers and oil circuit breakers; also a newly developed machine, and process for removing carbon in suspension from circuit breaker oil. Other features of the display will be meters, safety switches, interior lighting equipment and a complete line of Micarta products.

C. H. Wheeler Mfg. Co., Lehigh and Sedgley Aves., Philadelphia, Pa., will have an exhibit consisting largely of types of the Radojet air pump, a sectional model showing the construction and operation. A combined inter and after condenser will be shown as used in connection with closed feed-water systems. Photographs will show several large condensers of the dual-bank type and various condenser auxiliaries. An especial feature will be views of the 70,000 sq. ft. condenser of the Richmond station of the Philadelphia Electric Co., both as assembled at the factory and as installed in the Electric Co.'s plant. The company will occupy booths 105-6.

Wheeler Condenser & Engineering Co., Carteret, N. J., will have a 2-pass condenser of new design, also an improved 2-stage air pump with inter and after condenser. The Wheeler cooling tower with enclosed sides operating on the counter-current principle, pressure-sealed hotwell pump to keep feed water free of air and low pressure film type evaporator will be shown. Also a new high-pressure submerged type evaporator which has been developed during the past year. Closed bleed heaters for regenerative feed-water heating, expansion joints, oil heaters, coolers and heat exchangers and centrifugal pumps are some of the other equipment to be found in booth 226, as shown by drawings and photographs.

Wolff and Co., Wrigley Bldg., Chicago, will show apparatus, made by the various companies which it represents, in booths 211-12. Andale single and duplex strainers for all kinds of heavy and light liquids and for gases; Andale duplex extractors for removing from feed water oil, grease or sediment which might form scale; Andale coolers for lubricating and transformer oil, water and other liquids; Andale heat exchangers for recovering waste heat; Andale inter and after coolers for use in air, gas, gasoline and solvent vapor systems. Fast's flexible couplings, made of metal throughout, positively lubricated and with double engagement, a permanent film of oil being forced between gear teeth by centrifugal force. Cleveland enclosed worm gear speed reduction units for general industrial use; Cleveland rear axle drives for motor trucks, tractors and industrial locomotives; Cleveland worm and gear sets for building into machinery as desired by manufacturers.

Wright-Austin Co., 315 West Woodbridge St., Detroit, Michigan, will have an exhibit of its extra heavy water gage for steam boilers, the new design weighted try cock, safety alarm water columns with reversible valve and removable seat and Monel metal whistle valves in booth 61. A special feature will be the Brownie low-water signal for small boilers operating in a float chamber outside the boiler and parallel with the water column.

Yarnall-Waring Co., Chestnut Hill, Philadelphia, will show its Yarway-Lea V-Notch Meter and Type B hollow piston blow-off valve in booths 277 and 78. The meter will have the mechanism exposed to show the recording and integrating action and the blowoff valve will be shown as arranged for extreme pressures with planetary gears and a crank on the hand wheel to facilitate opening and closing. The Yarnall-Waring spray nozzles will also be shown.

Electric Welding Used in Constructing Lincoln Motor

IN A NEW MOTOR recently developed by the Lincoln Electric Co., Cleveland, Ohio, electric arc welding has made possible all steel construction. Cast iron has been displaced by steel throughout in both the rotor and the stator, making not only a machine that is light, strong and well ventilated but, it is claimed, one that will also withstand extremely severe usage.

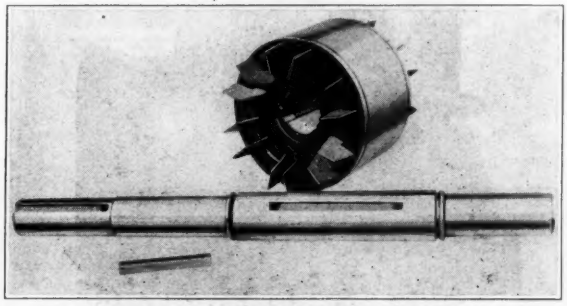


FIG. 1. TYPE OF SHAFT USED IN THE LINCOLN MOTOR AND THE TYPE OF VANE USED ON THE ROTOR

In this motor the frame or end rings are made from a standard steel angle, rolled into a circular shape by special machinery and the ends electrically welded. This construction results in a frame that it is claimed can be hurled across a room or dropped from a height onto a concrete floor without danger of breakage.

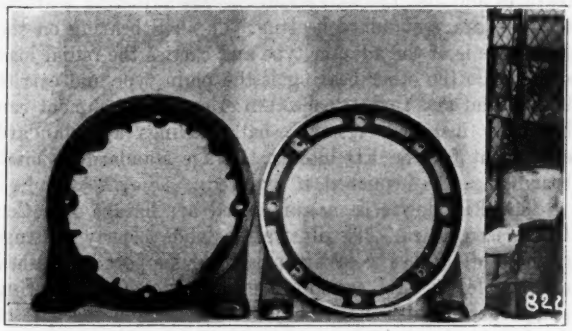


FIG. 2. SHOWING DIFFERENCE BETWEEN WELDED STEEL AND CAST IRON END RINGS. CAST IRON RING AT THE LEFT

The stator is built up of thin sheets or laminations pressed between the end rings under hydraulic pressure and, while thus compressed are hot riveted together. In this way they are held firmly between the end plates with no danger of them working loose.

The use of steel insures ample ventilating space. The cross-section of the steel parts are small, allowing more space for the circulation of air between the frame and the windings. To increase the circulation of air through the motor, ventilating vanes are provided on the rotor and a steel deflector is welded to the inside of the end brackets so as to direct the air currents in the proper course.

The feet of the motor are of drop forged steel, electrically welded to the steel frames. A jig with perfectly plane surfaces is used for holding the feet and stator during the welding process, so that the feet are always parallel to the shaft and will not rock when mounted on a true base.

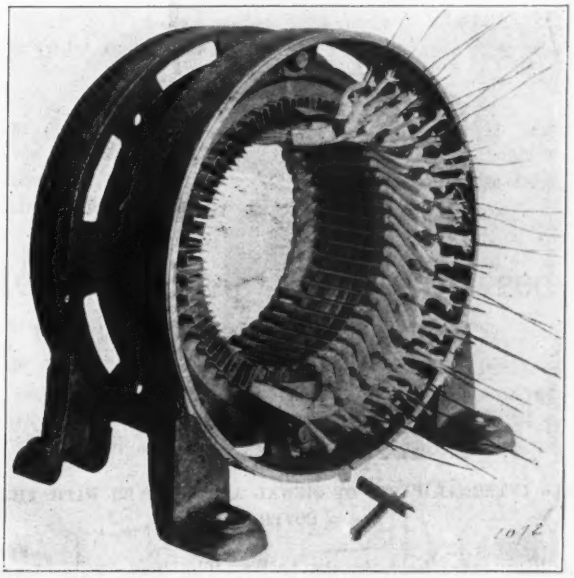


FIG. 3. SHOWING AIR SPACES PROVIDED, THE WELDED FEET, AND METHOD OF WIRING

Rotor laminations are assembled in the same manner that the stator laminations are assembled, that is, they are placed under hydraulic pressure and hot riveted. The windings or copper rods are not depended upon to hold the rotor together. End rings are made from strips of copper bent into circular shape and welded. Then end rings are punched and are put over the drawn copper rods which have been inserted in the rotor. The whole rotor is then placed in an automatic machine and the rods and rings welded together.

Even the bearing shells on the new Lincoln motor are of wrought steel instead of a casting, making them stronger, and thinner in section and allowing more babbit metal lining and a larger shaft. One of the smallest, yet most important parts of a motor is the oil ring. In the Lincoln motor this part is made of two dished steel rings welded

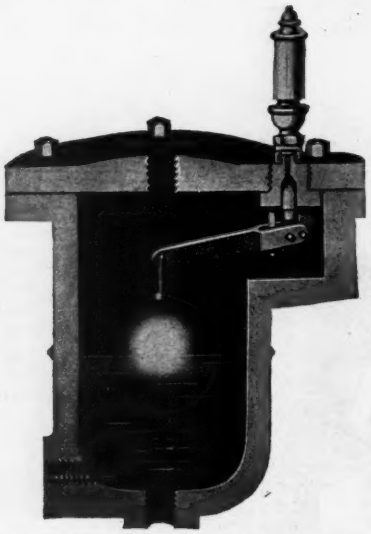
together, forming a deep groove in the center which carries the oil to the top of the shaft. This type of ring, it is apparent, can carry much more oil to the shaft than an ordinary ring not fitted with a groove.

These motors are built in sizes of from 1 to 500 hp. and for all voltages from 110 to 2300 v., two or three phase alternating current. They can be furnished standard for 25, 30, 40, 50 and 60 cycles.

Low Water Alarm for Small Boilers

FOR SMALL boilers a low water alarm, known as the "Brownie" boiler water signal and designed for pressures from 3 to 150 lb., has recently been marketed. This signal, shown in the accompanying illustration, has only three moving parts and all internal parts are attached to the cover as shown and are removed with it.

This signal is particularly adapted to small boilers. It may be connected with tees to the water column without



ALL INTERNAL PARTS OF SIGNAL ARE REMOVED WITH THE COVER

drilling extra holes in the boiler. The lower water level connection on the body of the signal is usually set level with the bottom connection of the water gage, so that the whistle will blow just before the water goes out of sight in the glass. The "Brownie" boiler water signal is made by Wright-Austin Co., Detroit, Mich.

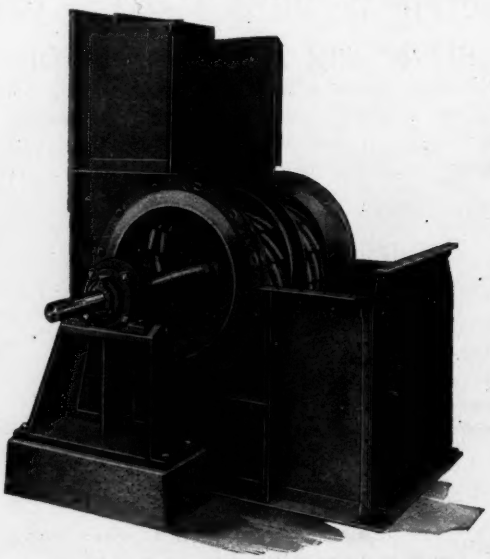
High Speed Blower Ruggedly Built for Forced Draft Service

DESIGNED TO MEET efficiently the requirements of the industrial power plant and the central station is the new Clarage Type FD Blower, a high speed, forced draft unit. It operates at the most desirable speeds for direct connection to either steam turbines or electric motors.

The FD Blower is equipped with two single inlet wheels of identical construction, as shown in the accompanying illustration. Blades for each wheel, 16 in number and pitched backward from the direction of air flow, are die stamped to insure uniformity of form, thickness and weight. They are ribbed to prevent distortion due to centrifugal force and are electrically welded into position.

Wheel hubs are semi-steel castings securely bolted and riveted to the heavy back plates. Further strengthening is obtained on the smaller sizes by four ½-in. tie rods running from hub to rim. On the larger sizes, more and heavier tie rods are furnished. The wheels are accurately tested for static and running balance.

The blower housing is fabricated from highest quality, blue annealed, open hearth steel of ample thickness. It is stiffened by bolting to a rigid angle and channel iron frame.



TYPE FD BLOWER WHEELS HAVE BACKWARD PITCHED BLADES, WELDED IN PLACE

being of the split type, as shown, a quarter section may be easily removed after installation for inspection of shaft and bearings. A clean-out door will be provided in the housing, if desired.

SKF balls and races mounted in special Clarage cases are provided. These bearings have the SKF self-alining features and also the well-known height adjusting features of the Clarage standard bearing. The ball bearing on the drive side is of the adapter type and carries the radial load only, while the other bearing is the plain type and carries both radial and thrust loads. An Alemite attachment can be easily installed. Though ball bearings are standard equipment for the FD blower, Clarage standard babbited bearings can be furnished, if required.

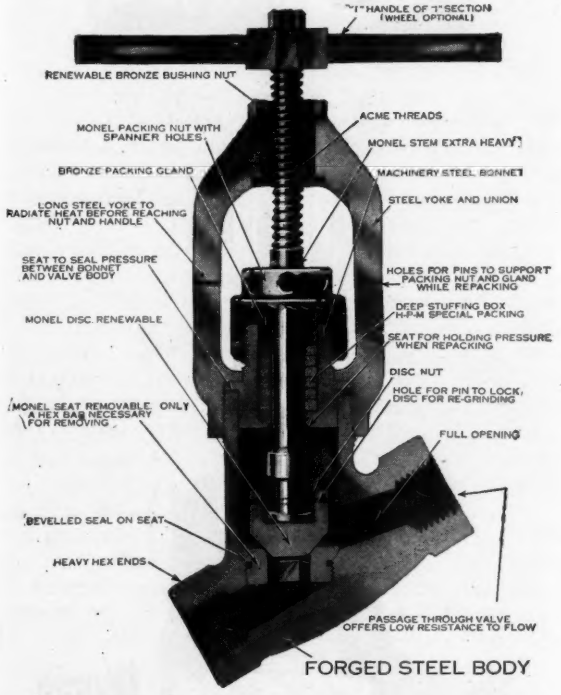
The FD blower is manufactured by Clarage Fan Co., Kalamazoo, Mich. The illustrations show clearly the ruggedness of the heavy cast-iron bearing supports furnished on the blower. Set screws on either side of the bearing seat, together with height adjusting screws in the base of the bearing, make this seat practically an adjustable sole plate. Heavy through bolts make the adjustment permanent, holding the bearings securely to the seat.

THE CHILDRESS ELECTRIC & ICE CO., Childress, Tex., is installing two 600-hp. De La Vergne Diesel engines which will give the plant a total capacity of 2080 hp. This plant is owned by the Texas Central Power Co. of San Antonio, Tex., and the company engineers are in charge of the installation. It is expected that one of the engines will be in operation by January 15 and the other by March 1.

"Forgsteel" Valve for High Pressures and Temperatures

DESIGNED EXCLUSIVELY for high temperature and high pressure work, the new "Forgsteel" valve has recently been placed on the market by The Hydraulic Press Mfg. Co., Mt. Gilead, Ohio. As shown in the illustration, the valve is of the straightaway type. The forged steel construction permits a valve body of uniform section throughout and is designed to eliminate unequal expansion or contraction.

This design provides full opening for steam flow and for confining the path of the flow to as few angles as possible in a valve made from a steel forging. The aim is to reduce friction losses to a minimum. Seat, disc and stem of this valve are made of non-corroding, acid-resisting steel or monel metal, designed to prevent wire-drawing and


"I" HANDLE OF "I" SECTION (WHEEL OPTIONAL)
RENEWABLE BRONZE BUSHING NUT
MONEL PACKING NUT WITH SPANNER HOLES
ACME THREADS
MONEL STEM EXTRA HEAVY
BRONZE PACKING GLAND
MACHINERY STEEL BONNET
LONG STEEL YOKE TO RADIATE HEAT BEFORE REACHING NUT AND HANDLE
STEEL YOKE AND UNION
SEAT TO SEAL PRESSURE BETWEEN BONNET AND VALVE BODY
HOLES FOR PINS TO SUPPORT PACKING NUT AND GLAND WHILE REPACKING
DEEP STUFFING BOX H-P-M SPECIAL PACKING
MONEL DISC RENEWABLE
SEAT FOR HOLDING PRESSURE WHEN REPACKING
DISC NUT
HOLE FOR PIN TO LOCK DISC FOR RE-GRINDING
MONEL SEAT REMOVABLE ONLY A HEX BAR NECESSARY FOR REMOVING
FULL OPENING
BEVELLED SEAL ON SEAT
HEAVY HEX ENDS
PASSAGE THROUGH VALVE OFFERS LOW RESISTANCE TO FLOW
FORGED STEEL BODY

THIS VALVE, OF FORGED STEEL CONSTRUCTION, IS DESIGNED WITH HEAVY YOKE AND STEM

to keep the valve tight when it cools after being closed while hot. Ample packing space is provided for quickly repacking the valve without disturbing operating conditions. The packing nut is of monel metal, a special acid-resisting steel. The yoke is of steel and the design provides a stem of unusual size, with Acme threads.

New Sewage Pump Design Permits Easy Inspection

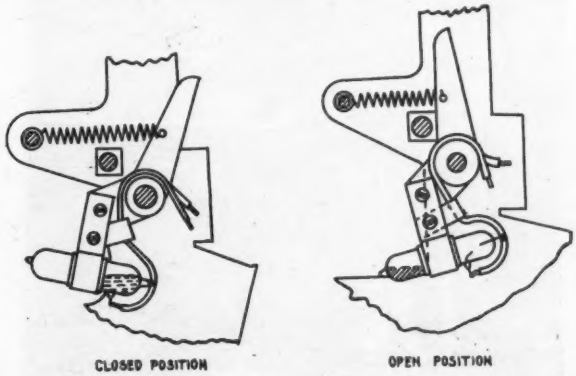
FOR HANDLING unscreened raw sewage in municipal service, a vertical shaft centrifugal sewage pump of new design, as shown in the accompanying illustration, has recently been brought out. This pump is of the two port, semi-enclosed impeller type. It is equipped with bronze covered steel shaft and the entire weight of impeller, shaft and shaft extension is carried on a self-aligning ball thrust bearing, mounted on a wide bearing yoke, which is supported on the pump volute, thus allowing the top plate to be raised to give access to the case without disturbing the bearing, shaft or impeller. The stuffing box is provided with a removable split gland to allow maxi-

THIS 10-IN. CENTRIFUGAL SEWAGE PUMP IS ARRANGED FOR BOTTOM SUCTION CONNECTION

mum clearance under the bearing. According to test curves obtained by Yeomans Bros. Co., Chicago, makers of this new pump, an efficiency of 65 per cent has been obtained when pumping 2800 g.p.m.

Mercury Contact Switch Used on Pyrometer Recorders

TO ELIMINATE electrical contact troubles in connection with pyrometer recorders, the engineers of Charles Engelhard, Inc., 30 Church St., New York City have developed a novel mercury contact switch which is



MERCURY CONTACT SWITCH IN CLOSED AND OPEN POSITION

unfailing in its operation. With this switch there can be no loose connections, and dirty contacts and corrosion are impossible.

The accompanying sketches show how simple the switch is in its design and how easily it operates. It is simply a small glass tube containing mercury, a minute quantity of oil, and an inert gas. Platinum electrodes pass through the glass and are sealed. In position A the mercury makes

contact with both of the electrodes, completing the circuit. To break the circuit the tube is tilted slightly to position B causing the mercury to flow away from the terminals to the other end of the tube. The maximum angle of tilt required to make the mercury flow back and forth is only 15 deg. when operated with extreme slowness. When tilted quickly as in actual practice in the pyrometer recorder the angle is less.

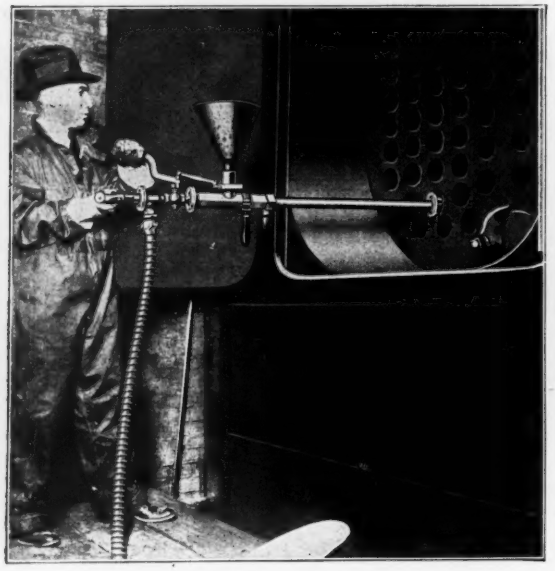
As may be noted from the sketches which are drawn full size, the switch is very small. The energy required to do the tilting is therefore so slight as to be almost negligible. Of course the switch is absolutely fume proof.

When used with pyrometers the required number of mercury contacts are all mounted side by side within the recorder case, requiring but little space. For example, where six records are to be made on one chart simultaneously, as is possible with this type of recorder, six mercury contact switches are employed. In other words, a separate mercury switch is used for each circuit.

This switch has a resistance of only 0.003 to 0.004 ohms, and never varies from these limits. The low and constant resistance of these switches combined with their absolutely fume and dust proof features permit this recorder to be used in connection with electric resistance thermometers and thermo-couples where extremely high precision is required and which would not be at all feasible with any other type of switch.

Sand Blast Flue Cleaner for H. R. T. Boilers

FOR CLEARING soot and baked deposits from the fire side of the tubes of a horizontal return tubular boiler, a new type of sand blast flue cleaner, known as the "Sandit," has been developed. This device consists of a



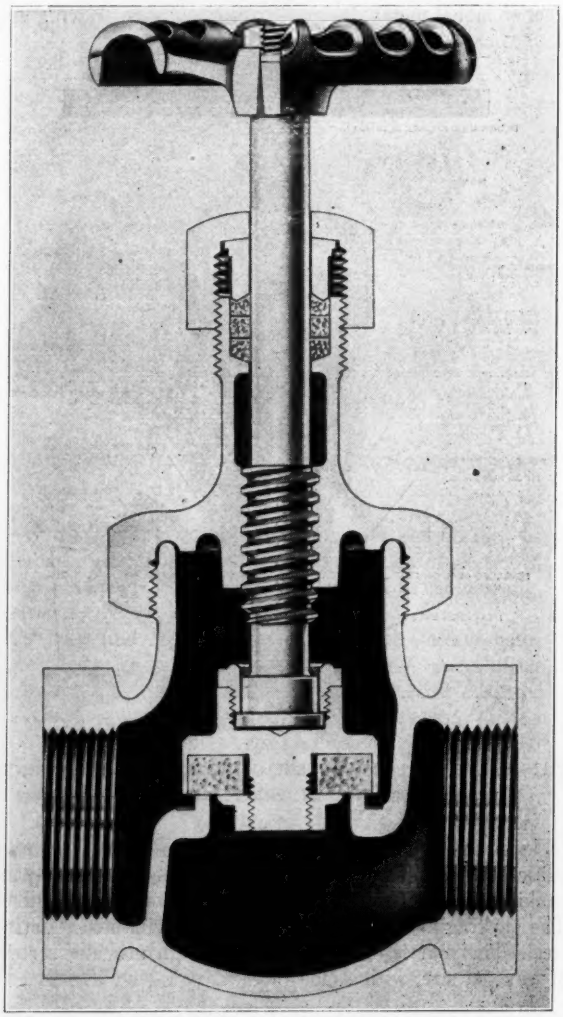
OPERATING THE SAND BLAST FLUE CLEANER

steam jet blower fitted with a sand funnel and controlling valve for admitting sand with the jet, as shown in the illustration.

By its scouring action, the sand blown through the tubes gives them a highly polished surface, without injuring them, it is claimed. Sandit operates best with steam pressure between 75 and 100 lb. per sq. in. The sand used in it must be dry and without pebbles in order to avoid choking the sand valve. The illustration shows the method of handling the cleaner, which is manufactured by The Perolin Co. of America, Chicago, Ill.

Valves for 225-lb. Service Incorporate New Features

MEDIUM PRESSURE bronze globe and angle valves for 225 lb. working steam pressure have recently been announced by Jenkins Bros. They have been designed to fulfill a need for a valve with the renewable disc



BALL JOINT IS FORMED WHEN BONNET OF THIS VALVE IS SCREWED ONTO BODY

feature that will withstand satisfactorily higher pressures than those recommended for standard pattern valves. An important feature of these valves is the bonnet and union, made in one piece to screw onto the outside of the body threads. The bonnet hexagons are made especially large, allowing easy removal of the bonnet without distortion. Of special interest also is the "ball joint" formed when the

bonnet and body are screwed together. This is a new feature and is intended to make a strong though easily removable joint.

These valves are regularly fitted with the Jenkins Special No. 800 composition disc for high pressure work. The spindle is made of manganese bronze, with large, powerful threads which are all in contact when the valve is closed. The stuffing box is deep, with plenty of asbestos packing, which is compressed by means of a bronze follower. A ventilated hand wheel of malleable iron is used. The valves are furnished in globe and angle types with screwed or flanged ends, in sizes from ¼ in. to 3 in.

Technical Societies of Massachusetts Hold Two-Day Session

AFFILIATED TECHNICAL Societies of Massachusetts devoted the entire two days of its meeting at Boston on Dec. 11 and 12 to discussions pertaining to fuel and power. The speakers and topics were: "Sources and Utilization of Coal," F. H. Daniels, vice-president and general manager of the Peabody Engineering Corp., New York City; "Diesel Engines," J. F. Hecking, Worthington Pump & Machinery Corporation, Cambridge, Mass.; "Possibilities of Obtaining Power from Public Service Corporations," L. R. Nash of Stone & Webster, Inc., Boston; "Power for Textile Mills," Charles T. Main, consulting engineer, Boston; "Power for Paper Mills," Joseph Warren, vice-president, S. D. Warren Co., Cumberland Mills, Me.; "Power for Industries Using Relatively Small Amounts of Power," K. D. Hamilton, George E. Keith Co., Brockton, Mass.; "Advantages and Disadvantages of the Use of High Steam Pressures," J. Pope, Stone & Webster, Inc.; "Utilization of Extraction Steam," Edgar A. Dickinson, General Electric Co., Lynn, Mass.; "The Supply of Industrial Power," W. H. Larkin, Jr., power engineer, United States Rubber Co., Passaic, N. J.; "Household Heating," Homer E. Linn, American Radiator Co., Chicago, Ill.

Those presiding over the sessions of the meeting were Dr. Ira N. Hollis, past president, A.S.M.E.; Dr. Samuel W. Stratton, president of the Massachusetts Institute of Technology; I. E. Moultrup, Edison Electric Illuminating Co., Boston; F. M. Gibson, plant engineer, American Sugar Refining Co., Boston. The annual dinner concluded the program, held at the Boston Chamber of Commerce.

Work Begins on Pit No. 4 Hydro Plant

WORK ON the dam and intake of Pit No. 4 hydro-electric plant of the Pacific Gas & Electric Co. will be carried on through the winter months with a minimum of 300 men. The new dam on Pit river will be about a mile and a half downstream from the power house of Pit No. 3. It will have a crest length of 410 ft. and will raise the level of the Pit 40 ft., forming another large lake in Pit River canyon.

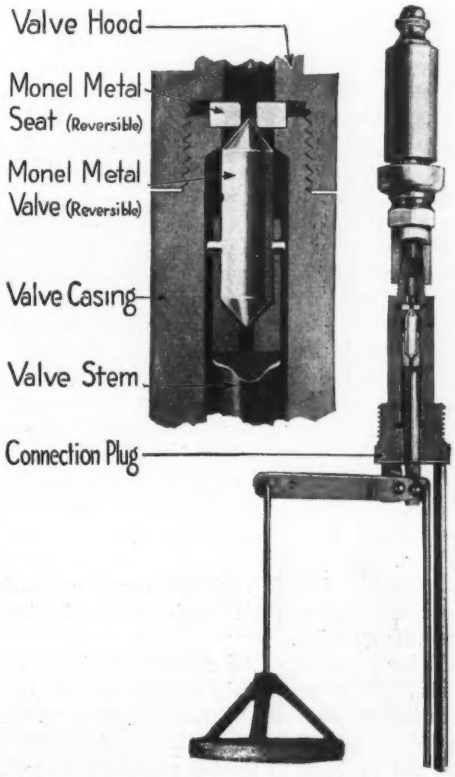
Cost of the dam, the foundations of which will extend about 60 ft. below the stream bed, is estimated at $1,750,000. This, however, is only a small part of the work, for the project includes a tunnel 4½ mi. long, a big power house and 10 mi. of railroad. Total cost, exclusive of transmission lines, will be approximately $15,000,000.

O. W. Peterson, engineer of general construction, and the men, who, under the direction of P. M. Downing, vice-president in charge of electrical construction and operation, built Pit No. 3, will carry out the new development.

Pit No. 4 will be the fifth of a series of eight P. G. & E. plants in the Pit River section, total cost of which will exceed $100,000,000. Four plants, Hat Creek No. 1 and 2 and Pit No. 1 and No. 3 with a combined installed capacity of 235,000 hp. are already in operation.

Monel Metal Whistle Valve of Compact Design

DESIGNED FOR use as a signal on water columns, the new monel metal whistle valve shown in the illustration has recently been featured by Wright-Austin Co., Detroit, Mich. The entire valve is outside of the water



WHISTLE VALVE IS DESIGNED FOR EASY ACCESS TO PARTS

column. By removing the valve hood and the valve casing, the design permits easy access to the valve and seat. The valve and seat are of monel metal and are reversible, as shown in the illustration, and are designed to give double length of service. Valve and seat can be reversed or renewed without detaching the column cover or any column connections.

SOOT REMOVAL AND PREVENTION compounds are being studied by the Bureau of Mines, Department of Commerce. In order to determine the effectiveness of such compounds for their stated purposes, a study is being made of the flue-gas temperatures and gas composition necessary for the reactions to take place both with and without the use of the compounds or other materials. The investigation will be extended to a study of the effectiveness of the compounds under conditions similar to those to which they are supposed to be applied.

Maine Power Law Meeting Disfavor

PASSAGE of the referendum in Maine allowing the use of the tides in Passamaquoddy Bay for the manufacture of hydro-electric power from plans by Engineer Dexter Cooper, and permitting the export of such of that power as is not required within the boundaries of the state, has started a well-defined program for the entire abolition of the law, passed in 1909, which prohibits export of power from Maine.

Proponents of the law at that time believed that if power was not exported, the cheapness of its manufacture in Maine from Maine's water power, would result in bringing millions of dollars worth of manufacturing into the state. Instead of obtaining this result, however, not a penny's worth has been brought to the state and now Maine's business men believe that if the law is not revoked, Canada or other states will take advantage of the opportunities existing and develop power lines which will deprive Maine of a market for hydro-electrical current which would otherwise easily belong to her.

"More than $50,000,000 would be spent in the development of power lines in Maine inside a very few years if the law prohibiting the export of power were repealed," declared Walter S. Wyman, president of the New England Public Service Co. and the Central Maine Power Co. at a meeting of the Maine State Grange in Bangor.

Mr. Wyman believes that Maine should at once start to develop its power resources and that its natural market would be in the direction of Massachusetts. "We will lose from $20,000,000 to $30,000,000 in taxes, more than five times that amount from industrial development, and will secure cheaper power—perhaps about one-half of the present cost, if the Maine Legislature will repeal that law," he declared.

So important does Mr. Wyman consider the situation that he would urge a special session of the Legislature to act upon the question.

Speaking a few days later at the Kiwanis Club in Portland, Me., Mr. Wyman again stressed the importance of the situation and declared: "Owners of 2,000,000 hp. on the St. Lawrence, 7,000,000 hp. in Ontario and 7,000,000 hp. more in the Province of Quebec are trying to work out a market in Massachusetts. Our undeveloped water powers have a big value now but we are not without competition. If we wait we may lose our opportunity for a generation or more."

At the New England Council meeting at Providence, R. I., in which every business and industry in New England was represented, called for the purpose of developing New England, an interconnection map was shown in which Maine was listed as a blank, so far as power for the rest of New England was concerned. The power lines stretch from Washington to Boston, through Western Massachusetts, into Vermont and Canada, but Maine was left out of the map. It is well-known that Maine alone could supply more than enough power for all of New England through development of certain of its water powers, a survey made two years ago showing this to be the case.

Reports to the Council showed that in the upper reaches of the Penobscot and Kennebec rivers of Maine alone, there could be developed annually 3,000,000,000-kw-hr. of cheap electricity, a quantity sufficient to last 100 yr. at the rate which Maine is now using it.

At the meeting of the Associated Industries of Maine held Dec. 15 at Portland, resolutions were unanimously adopted urging the repeal of the law. A special committee consisting of ex-Governor William T. Cobb, Dr. Walter E. Elwell and Philip Dana has been named to carry the project for the repeal forward.

The New England Council voted unanimously to ignore state lines in the development of New England and will petition the Maine Legislature that such action be taken with relation to its power ban.

The Maine State Grange and many civic and business clubs have taken similar action. The movement has started and is gaining in impetus almost daily. Upon its success depends whether or not hundreds of millions will be spent in Maine power development during the next decade.

Hydro Plant for Small Powers Uses Propeller Runner

FOR SMALL water powers, where relatively low heads are available, such as are often available in farming districts or isolated locations, an interesting self-contained hydro-electric generating unit has been developed, as shown in the accompanying illustration. The unit constitutes a complete hydro-electric plant, consisting of turbine, governor, generator and instrument board.

THIS ONE-KILOWATT HYDRO PLANT IS COMPLETE WITH PROPELLER RUNNER, GOVERNOR, VALVES AND SWITCHBOARD

The turbine runner itself is of the high speed propeller type and the water supply and speed are controlled by a plug valve operated by a flyball governor mounted on the shaft just below the generator. In the photograph this governor is concealed by the instrument board. The unit is totally enclosed with a plate steel housing, and the method of installing it on I-beam supports across the spillway is evident from the photograph. The unit is self-contained and is practically automatic in operation.

Units of this type are furnished at present for supplying either a.c. or d.c., usually at 125 v., in capacities vary-

ing between 1 kw. and 5 kw., depending, of course, on the head of water available. They find application in construction work, as exciters and night generators for small industrial plants, in camps or on individual farms.

News Notes

YEOMANS BROTHERS Co., of Chicago, announces the appointment of David W. Burgoon as sales manager for the company.

K-B PULVERIZER CORP. has moved its New York offices to the Grand Central Terminal Bldg., 70 East 45th St., New York.

B. K. MOULD took charge of the New York office of C. H. Wheeler Mfg. Co. on Jan. 1, at 50 Church St., and with him is associated W. W. Clinedinst.

EDWARD EVERETT ARNOLD, president of the Oneonta Light & Power Co., the Pawtuxet Valley Water Co. and other similar companies, died at his home in Providence Dec. 16, aged 72.

LINK-BELT Co. of Chicago announces the opening of a branch office in the First Wisconsin National Bank Bldg., Milwaukee, Wis., where R. C. Kendall will be in charge.

THE VERNON ELECTRIC & ICE Co., Vernon, Tex., has recently completed the installation of a 575-hp. McIntosh & Seymour Diesel engine and is planning the installation of another engine of the same type and capacity as soon as it arrives from the factory.

THE MONTPELIER & BARRE LIGHT & POWER Co. of Vermont, which is a Massachusetts corporation, is floating an additional issue of $584,000 first refunding mortgage five per cent convertible gold bonds for extension of service. The company is one of those operated by the Charles H. Tenney & Co. interests.

GARRETT SCHENCK, JR., aged 42, son of Garrett Schenck, president of the Great Northern Paper Co., died at his home in Newton, Mass., Dec. 14. The younger Mr. Schenck was president and manager of the Millinocket & East Millinocket Light Co., vice-president of the Great Northern Paper Co., president of the Knox Lime Co. and a director of other companies.

AS A TRIBUTE to his long and successful record with the Walworth Co., a dinner was tendered to John C. Bannister, vice-president in charge of engineering of the company, who retired from active work on January 1. This farewell dinner was given at the Harvard Club in Boston on December 21, at which 28 men, including the executive officers of the company and a number of Mr. Bannister's most intimate associates in the Boston office, were present. F. H. Morehead, chief engineer of the company, takes over Mr. Bannister's responsibilities for the Walworth Co.

LINK-BELT Co. of Chicago, Ill., has recently created the position of chief engineer of the company which will be filled by W. W. Sayers, formerly chief engineer of the Philadelphia plant. His new headquarters will be at the general office in Chicago. Geo. L. Morehead, for the past six years attached to the management of the several Indianapolis plants, takes on the duties of manager of the Philadelphia plant.

ELLIOTT Co., Jeannette, Pa., has been awarded the contract for the condensers for the new steam power station of the Southern Power Co. which is now being built on the Yadkin River, two miles from the City of Charlotte, N. C. The two condensers are each of 54,000 sq. ft. size, and are furnished complete with auxiliaries. The condensers are of the two-pass type, standard Elliott Surface Condenser design, all auxiliaries motor-driven, except the air ejectors which will operate with steam at 375 lb. pressure. The condensers are expected to give an average vacuum of 29-in. the year around. They will serve two 37,500 kw. General Electric turbines.

A NEW COMPANY has been organized, known as the Holyoke Power & Electric Co., Holyoke, Mass., with capital of $1,000,000 for the expansion of the present business of the Holyoke Water Power Co. The charter of the Water Power Co. limits the use of power to Holyoke while the charter granted the new company permits its export anywhere, so that power now going to waste may be utilized.

AT THE Houston, Tex., section meeting of the A. S. M. E. on Jan. 19, E. T. Keck, superintendent of the Texas Power and Light Co., will speak at the University Club at 8 p.m., on Pulverized Fuel.

The Philadelphia section will hold a joint meeting with the Engineers' Club of Philadelphia on Jan. 19, 7 p.m., on the subject of Oil and Gas Power. The Western Washington section will meet Jan. 22 at the Engineers' Club of Seattle at 8 p.m. A. D. Thomas of The Texas Co., speaking on Lubrication Engineering.

W. H. NICHOLSON & Co. has recently appointed the following concerns as representatives in the southeastern states: The A. K. Miller Engineering Co. of Mobile, Ala. and New Orleans, La., will handle the states of Louisiana, Mississippi, Southern Alabama and Florida. Smith-Meadow Supply Co. of Birmingham, Ala., will cover the northern half of Alabama. J. R. Whitman of Atlnata, Ga., will cover the entire state of Georgia, and The M. K. Moore Co. of Charleston, S. C., will cover North and South Carolina.

GENERAL ELECTRIC Co. has announced that the company has definitely decided to purchase a site for a manufacturing establishment in the City of St. Louis. The tracts of real estate selected contain in the aggregate about 155 acres, of which all but 11 acres are within the city limits of St. Louis; the remainder lies just beyond the city limits in St. Louis County. The property in general lies between the Belt Line of the Terminal Railroad Association and Goodfellow Avenue. It also has a frontage on Bircher Avenue.

THE INDIANA ELECTRIC CORP. at its Wabash River Steam Station about eight miles from Terre Haute has recently put in operation a third turbo-generator with a capacity of 20,000 kw. The installation of this unit was made by Stone & Webster, Inc., who in 1922 built the initial development for this station, which consisted of two 20,000 kw. turbo-generators, four boilers of 1726 hp. capacity each, and coal handling equipment having a capacity of 100 tons per hour. As a result of increased load four additional boilers of the same size were installed in 1924 and 1925 and the boiler room was extended to permit the addition of two more. The turbine room was extended at the same time for the third 20,000 kw. unit which is now in operation. The coal handling equipment has been doubled so that it can supply the station with its ultimate capacity of 100,000 kw. There are at present two 25,000-kv.a. transformer banks, stepping up the current to 132,000 v. for transmission to Indianapolis about 75 mi. away, one 25,000 kv.a., 66,000-v. bank and one 9000 kv.a., 33,000-v. bank, feeding into the distribution system.

THE CENTRAL & SOUTHWESTERN UTILITIES CO., a Delaware corporation, has made application for permit to do business in the state of Texas. The company has an authorized capital stock of 1,200,000 shares with $24,000,465 paid in and controls through the entire common stock ownership the Public Service Co. of Oklahoma, Chickasha Gas & Electric Co., Central Power & Light Co. and Southwestern Securities Co. These operating properties furnish utility services to approximately 250 cities and towns in Kansas, Oklahoma, Arkansas, Louisiana, Mississippi and Texas. Among the directors of the company are Samuel Insull and Martin J. Insull of Chicago; F. W. Insull, Tulsa, Okla.; G. W. Fry, Abilene, Tex., and J. C. Kennedy, San Antonio, Tex. Mr. Kennedy will be in charge of the Texas business of the corporation which will have its principal office in San Antonio.

AS THE RESULT of a large quantity of fine sand washed in at the intakes of the Lewiston, Me., water system at Lake Auburn, a peculiar situation has arisen. In some instances hydraulic elevators and water power machinery have been forced to shut down because of the sand ruining the valves, while large users of water, such as laundries, mills, photographic studios and similar places, temporary filtration of all water had to be made before it could be used. A combination of wind and ice is said to have caused the difficulty. The city plans to take steps at once to prevent any recurrence of the trouble.

THE WEST PENN ELECTRIC CO. has been formed under Maryland laws, with capital for taxation purposes stated at $172,000,000, as a holding company for the electric utilities of the American Water Works & Electric Co., New York, and other properties to be acquired. The new organization will acquire the Potomac Edison Co., Cumberland, Md.; West Penn Co., Pittsburgh, Pa., and West Virginia; and the Keystone Power & Light Co., Maryland. The central stations under the new control have an aggregate capacity of 500,000 hp., with transmission system of 2,100 miles. The territory covered by the consolidation totals 22,000 sq. mi., serving a gross population of 1,100,000 persons. Practically all lines west of Frederick, Md., will be under this direction in the future.

BUFFALO GENERAL ELECTRIC CO. is planning the addition to its River Station of a 60,000-kw. steam turbine which it plans to have in operation by the fall of 1926. This is a single unit machine, operated at 1500 r.p.m., the steam pressure being 250 lb. gage and with superheat of 250 deg. The present capacity of the station is 95,000-kw. which is made up of three 20,000-kw. and one 35,000-kw. turbine generators. Directly connected to the generator terminals there will be a 3-phase auto transformer of 60,000-kw. rating. This, it is reported, will have a higher rating and greater physical dimensions than any transformer now in use in this country. It will step the voltage up from 12,000 to 24,500-v. This new equipment is being supplied by the General Electric Co.

THREE TURBINE generators, totaling 130,000 kw. in capacity, are to be added to the facilities of the Detroit Edison Co. Two of these machines, necessary to care for the ever-increasing demands of Detroit for power, will be placed in the Trenton Channel Station and the other in the Marysville Station. The turbines for Trenton Channel have capacities of 50,000 kw. each; the Marysville unit is rated at 30,000 kw. It will be possible to add but one more unit to the Trenton Channel Station. All of the turbines are being made by the General Electric Co. The larger units are rated at 50,000 kw., 1200 r.p.m., 12,200 v., 3-phase, 60-cycle, with direct-connected exciter, and operating at 375 lb. pressure. Deliveries have been promised for August and October, 1926. The third unit is rated at 30,000 kw., 1800 r.p.m., 12,200 v., 3-phase, 60-cycle, with direct-connected exciter, and operating at 275 lb. pressure. Delivery will be made in July, 1926.

CHARLES DAVID MARX, professor emeritus of civil engineering in Leland Stanford, Jr., University, has been elected chairman of the Engineering Foundation Committee on Arch Dam Investigation. He succeeds Professor C. Derleth, Jr., of the University of California, who relinquishes the chairmanship on account of ill health, but who will continue as a member of the Committee. Announcement of Professor Marx's election was made following a meeting of the Committee at Fresno, Cal., when plans were made to push the work on the experimental arch dam now under construction on Stevenson Creek, a tributary of the San Joaquin River, about sixty miles east of Fresno. W. A. Slater, engineer-physicist of the U. S. Bureau of Standards, has, it is announced, taken charge of tests at the dam. More than 1200 cu. yd. of rock have been excavated, and actual construction of the dam is under way, according to a progress report of operations issued by the Foundation.

Books and Catalogs

THE FOURTH EDITION of The Guide issued by the American Society of Heating and Ventilating Engineers, 29 W. 39th St., New York, is now available. The Guide is bound in blue cloth, stamped in red and gold, and contains 584 pages.

Entirely new data on Heat Loss from Buildings have been contributed, Systems and Piping for Steam Heating is a new chapter and new data on Insulation have been compiled. A new chapter on Automatic Temperature Regulation has been written, together with new material on Hot Water Heating and each of the other chapters in the heating section has been revised.

In the ventilation section, many changes will be noted, one of the important additions being the chapter on Cooling in Air Conditioning Work. Chapters on Air Washers and Filters and Systems of Ventilation have been incorporated. A new department has been added to The Guide known as the Consulting Service Section and a new index to the text section has been compiled. As in former years a roll of membership of this Society is included which shows both alphabetical and geographical lists.

SEVERAL YEARS AGO an investigation was begun at the University of Illinois to determine the efficiency of spur gearing and the breaking strength of the teeth under various conditions of load and speed. Because of the growing importance of data on the wear of gear teeth it seemed advisable to depart somewhat from the original plan and to make a study of the durability of spur gearing rather than the breaking strength of the teeth.

The purpose of Bulletin No. 149 of the Engineering Experiment Station, entitled "An Investigation of the Efficiency and Durability of Spur Gears," written as the result of this investigation, is to furnish reliable information on the efficiency of spur gearing and data on the change and the rate of change in the profiles of spur gear teeth subjected to wear.

Copies of Bulletin No. 149 may be obtained without

charge from the Engineering Experiment Station, Urbana, Illinois.

FOR THE USE OF ENGINEERS who have occasion to calculate quantities connected with the expansion of steam a convenient chart is being distributed by the De Laval Steam Turbine Co. of Trenton, N. J. The Mollier diagram is printed upon a stiff sheet of Bristol board, attached to which is a scale which can be broken off and used directly for measuring heat available, spouting velocity, pounds of steam per horsepower-hour and duty between given pressure limits on the entropy diagram; that is, the chart and scale give these quantities directly for a perfect heat motor. If the steam consumption of an actual engine or turbine is known, the efficiency ratio is found by a simple division. The quality of the steam at the end of a perfect expansion or at the end of actual expansion of known efficiency or steam consumption is also read off immediately from the chart. Copies will be sent upon request.

"WHERE DIESEL ENGINES HAVE Solved Power Problems" is the title of Bulletin No. 39, recently issued by Nordberg Manufacturing Co., Milwaukee, Wis. This bulletin, which is made attractive by the use of large halftone cuts and tint blocks, gives illustrations of many installations of Diesel engine units and in many cases gives data taken from the plant's performance records, citing costs of power in various stations illustrated.

PENNSYLVANIA DUPLEX single stage and 2-stage cross compound air compressors are described in Form No. 126, recently issued by the Pennsylvania Pump & Compressor Co., Easton, Pa. The pamphlet illustrates and describes the various details which go to make up the compressor and contains capacity tables of the various sizes of compressors manufactured.

ALLIS-CHALMERS CENTRIFUGAL boiler feed pumps are described in a recent bulletin of the Allis-Chalmers Mfg. Co., Milwaukee, Wis. Construction and installation views of various types of the multistage boiler feed pump are shown, together with data on pump capacities, pump drives, suction lifts, feed water regulation and the like.

"TENTACULAR," THE SUCTION BELT, is described in a bulletin issued by Alexander Brothers, Inc., Philadelphia, Pa. This belt is designed to eliminate belt slip and to give the required flexibility without the use of excessive amounts of belt dressing, tallow being the only material used on the belt.

POWER PLANT EFFICIENCY Co., Indianapolis, Ind., is sending out a bulletin describing Interlocking Sectional Tile Baffles. These baffles are designed with special joints at the edges to eliminate the use of cement and at the same time to provide a rigid and leak-proof construction.

THE CLEVELAND WORM & GEAR Co., 5238 E. Eightieth St., Cleveland, Ohio, has recently issued its Bulletin No. 105 dealing with worms and gears. These devices are illustrated with both halftones and line drawings and tables of dimensions are published in the bulletin.

GENERAL ELECTRIC STEAM TURBINES rated at 500, 600 and 700 kw. are described in Bulletin GEA-235, just issued by General Electric Co., Schenectady, N. Y. The general principles and advantages of steam turbines are discussed, and sections and steam path diagrams are shown.

"MODERN SPEED REDUCTION" is the title of a booklet published by Boston Gear Works Sales Co., Norfolk Downs, Mass. This bulletin describes various types of speed reduction units and gives tables of dimensions and information of value to the designer.

THOROUGHLY-COVERING the methods and procedure in oil burner testing wherever the burners are fired under boilers or in warm air heating plants, a 28-page bulletin has just been issued by the American Oil Burner Association, 350 Madison Ave., New York, N. Y. The bulletin provides under one cover all the important tables and formulas needed in testing burners, so that those in charge of the test need not suffer the usual annoyance and loss of time due to having to use a number of handbooks or references.

ELECTRICALLY OPERATED FLOW METERS recently developed by General Electric Co. are shown in various types in Bulletin GEA-133.

KEELER BOILERS are fully described and illustrated in a new catalog issued for distribution at the New York Power Show by E. Keeler Co., Williamsport, Pa.

GENERAL CATALOG No. 28 has recently been issued by the McAlear Manufacturing Co., 1901 So. Western Ave., Chicago, Ill. The products manufactured by this company consist of specialties for steam, water, air, gas and oil.

GENERAL REFRACTORIES Co., Philadelphia, Pa., has just published a small bulletin discussing the advantages of sized brick in producing better refractory wall construction and saving time and labor in setting.

WILSON-SNYDER MANUFACTURING Co., Pittsburgh, Pa., has just issued a pamphlet announcing its solid and hollow flanged and cast ball valves which have particular advantages in the handling of heavy liquids and liquids at high temperatures.

BOYLSTON STEAM SPECIALTIES are described in Catalog No. 14, recently issued by the Boylston Steam Specialty Co., 122 W. Illinois St., Chicago, Ill. This is a general catalog describing the company's various specialties and pointing out their uses in power plants.

THE MCLEOD & HENRY Flat Suspended Furnace Arch is described in Bulletin 162 recently issued by McLeod & Henry Co., Troy, N. Y. The bulletin discusses the general application of the suspended arch to boiler furnaces and gives details of the refractories and suspension methods used in this arch.

BULLETIN No. 25 of the Rollins Engine Co., Nashua, N. H., describes the Rollins engine. Photographs and discussion of the various parts of the engine are given, together with data on performance and convenient tables for finding M. E. P. of steam engines when initial pressure and cutoff or number of expansions are known.

NEEMES GRATES are described in Bulletin No. 103 just sent out by Neemes Foundry, Inc., Troy, N. Y. This describes the various types of shaking and dumping grates made by this company, showing details of construction and methods of installation. Copies of the bulletin may be obtained on application to their main office.

SMALL DIESEL ENGINES in sizes from 6 to 50 hp., connected to air compressors, pumping sets, generators and the like, are described in Bulletin No. 30 of the Hill-Diesel Engine Co., Lansing, Mich. These small units find application in industrial plants, marine plants and for various types of standby service. The engines are designed for hand starting, without the use of a torch or electrical ignition.

RECENT DEVELOPMENTS in temperature measuring, in-

dicating and recording instruments, as incorporated in new models of equipment made by Taylor Instrument Companies, Rochester, N. Y., are described completely in Catalog Part 4000, which has just been issued. All types of indicating and recording pyrometers are described as well as thermocouples, protecting tubes and an interesting discussion of thermocouple installation methods.

FEED WATER HEATERS of all types and their application in detail are discussed in a catalog just issued by the Cochrane Corp., Philadelphia, Pa. This catalog describes various types of the open heater, the V-notch weir heater and various types of stage feed water heaters.

BULLETIN No. 5-N, describing recooling spray nozzle systems, has just been received from Schutte & Koerting Co., Philadelphia, Pa. Design of the nozzles, performance of spray ponds and design and installation data are attractively presented.

LOCK JOINT PIPE Co., Ampere, N. J., has issued a new bulletin describing Lock Joint reinforced concrete pipe. The bulletin contains a discussion of the various methods of fabricating this pipe and of forming the joints. The bulletin is copiously illustrated with views of installations of Lock Joint pipe in various parts of the country.

LIBERTY SURFACE CLEANERS are described in Bulletin Z-3, issued by Liberty Mfg. Co., Pittsburgh, Pa. In these cleaners a wire brush of special construction is rotated either by a pneumatic or an electric motor. Bulletin Z-4 also issued by Liberty Mfg. Co. describes Liberty tube cleaners for railway locomotive work.

BRONZE AND FORGED STEEL valves are described in Bulletin No. 8-A issued by Schutte & Koerting Co., Philadelphia, Pa. The bulletin describes bronze valves of various types for 250 lb. working pressure, bronze hydraulic valves of 1500 lb. and 4000 lb. pressure and forged steel stop valves for pressures from 400 lb. to 1200 lb.

BULLETIN 635-X, recently issued by Harnischfeger Corp., Milwaukee, Wis., is devoted to truck and trailer cranes. In the bulletin are given the uses of these trucks and trailers, capacities available, details of construction features and brief specifications, together with illustrations which give the reader a good idea of their construction and uses.

THE FIFTH EDITION of a booklet published by the Griscom-Russell Co., New York, discussing distillation as a means of producing pure boiler feed makeup water, is now being issued. It has been completely revised to cover latest developments in the central station and industrial plant fields; many new diagrams are included to show layouts for various operating requirements and the conditions under which evaporators can be used usually are thoroughly explained.

THE MITCHELL-RAND MFG. CO., New York, has just prepared a wall sheet of the tables most frequently used in both electrical and machine shops. Data on the carrying capacities of copper wire was supplied by the U. S. Bureau of Standards; sizes of drills were obtained through the co-operation of various manufacturers; and many other useful tables are incorporated. Mitchell-Rand Mfg. Co. manufactures insulating materials and the wall sheet will be sent to individuals and companies having an interest in these products.

BRISTOL-DERR WATER LEVEL GAGES for steam boilers are described in Bulletin No. 339 of The Bristol Co., Waterbury, Conn. To operate this gage a series of thermocouples is installed to measure the temperature between the steam space and the water space in a water column, the variation in temperature as the water rises and falls causing a varying electric current, which is transmitted by cable to suitable recording and indicating instruments. The bulletin shows construction details and installation photographs of this water level gage.

NATIONAL LAMP WORKS of General Electric Co., Nela Park, Cleveland, O., announces that several engineering development bulletins on illumination are now available.

Bulletin 41-C discusses illumination designed for industrial and commercial interiors. Bulletin 50 treats of Electrical Advertising and Bulletin 51 of night lighting for outdoor sports. Bulletin 42-A presents factory lighting designs, showing proper layout for various common factory interiors. Bulletin 7-C discusses fundamentals of illumination design and other bulletins treat the lighting of stores, streets, motor vehicles and homes. Copies of these booklets may be obtained on application to the National Lamp Works.

ELLIOTT Co., Jeannette, Pa., has just issued Bulletins K-1 and S-7 and C-4. Bulletin K-1 described the distinctive features of the Faber self cleaning blowoff valve, showing by illustrations the construction of the valve and giving data on its operation and on the dimensions. The valve is made in 2-in. and 2½-in. sizes for 500 lb. working pressure. Bulletin S-7 described the "C" Lagonda non-return valve, the Class "ID" and Class "XD' stream line flow non-return valves. These are supplied for service at ordinary pressures and also for high pressure, high temperature work. Bulletin C-4 describes the air leakage meter for measuring directly in cubic feet the air leakage into the surface condenser and discusses methods of using the meter.

NEW BULLETINS have just been issued by the State Geological Survey at Urbana on the Coal Resources of Western Illinois, Coal Losses in Illinois, the significance of carbon ratios in regard to the occurrence of oil and gas, and proper methods of testing for oil structures with citation of some areas deserving such testing. Bulletin 29 on "The Coal Resources of Western Illinois" by Harold E. Culver, covers an area of about 11,000 sq. mi. Bulletin 30 on "Coal Losses in Illinois" written by the late C. A. Allen, and deals with the losses involved in the present methods of mining coal in Illinois. Problems involving surface subsidence and mine labor are not included. The report comprises 34 pages. The report on "Carbon Ratios and Petroleum in Illinois," by Gail F. Moulton, is known as Report of Investigations No. 4. It defines what is meant by carbon ratios, points out the relation of the oil sands to structural features, the relation of the character of the coal to these structural features, and presents certain conclusions concerning oil possibilities in different parts of the State. The report on "Proper Testing for Oil Structures in Illinois and some Areas deserving such Testing" by Gail F. Moulton is known as Report of Investigations No. 6. It outlines the most satisfactory method of exploring for oil in Illinois and calls attention to some of the areas which are worthy of testing.

All the above mentioned bulletins are obtainable at a small cost from the Chief, State Geological Survey Division, Urbana, Illinois.